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An Illustrated Weekly Journal

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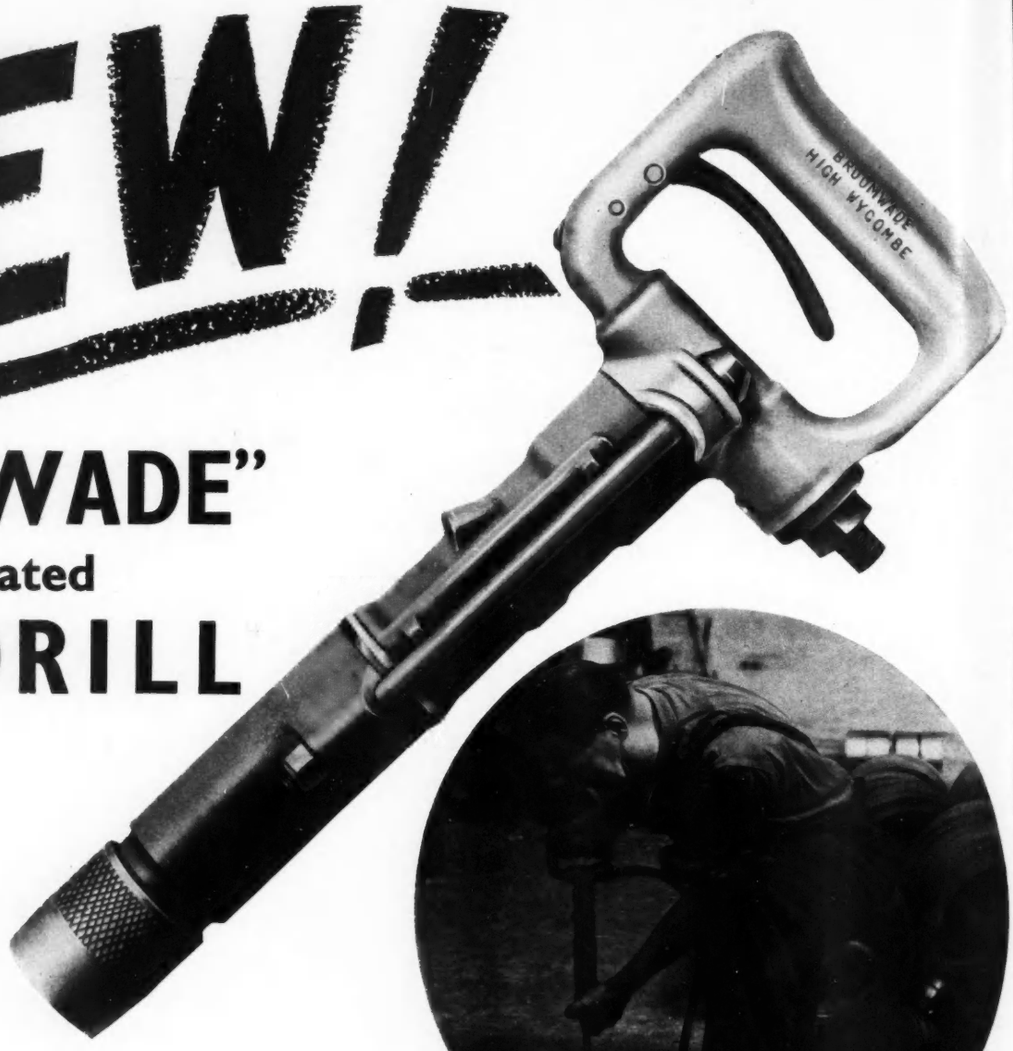

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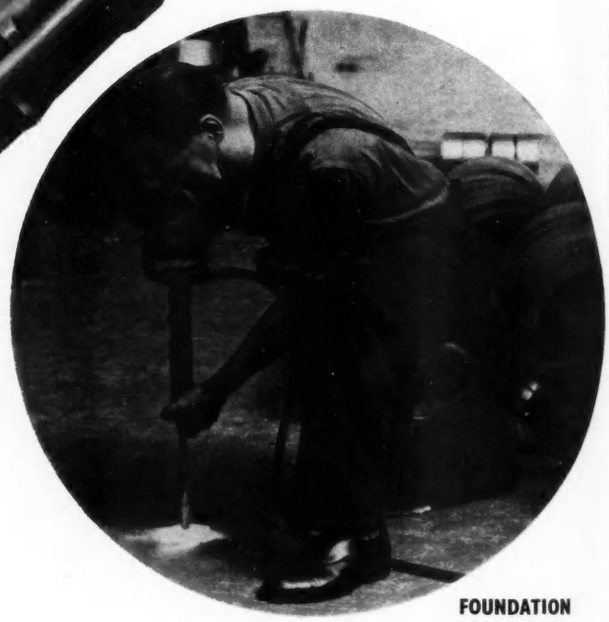

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ENGINEERS WANTED

THE continued state of full employment, combined with a rapid expansion of the engineering industries, has created problems of recruitment to the higher ranks of those industries even more serious than the shortage of craftsmen and production workers. Equally, the phenomena to which the shortages of scientifically and technically trained staff give rise are subject to similar misunderstanding and misinterpretation. A feeling has grown up among some sections of the engineering industries that the great increase that has taken place since the war in the number of engineers trained at the universities has led to a lowering of the standard of the graduate engineer and, what some of them dislike more, of the number and quality of boys available for training as student apprentices.

The complex relationships between the several factors which have given rise to this feeling are well brought out in a report, published this week, by the Committee on Scientific Manpower of the Government's Advisory Committee on Scientific Policy.* This is based on inquiries made of 50 large firms with an average annual intake, during 1951 to 1953, of 935 first-degree graduates, mostly in technology, equivalent to at least 50 per cent. of the total intake to industry of engineering graduates from the universities. In addition, the firms recruited during the same period 293 holders of National Diplomas and 1,173 student apprentices.

It is not surprising that the experiences and opinions of these firms varied, or that some industries such as electrical engineering, instruments and electronics should show a greater appreciation of the university-trained man than some of the more traditional branches of mechanical engineering. Nevertheless, the preference of the aircraft industry for the student apprentice and the comparative lack of interest in either by shipbuilders and motor-car makers requires further investigation with reference to their rate of technological progress. That a shortage of graduate engineers still exists is shown by the fact that supply is falling short of demand by some 25 per cent. and the heavier industries suffer by virtue of the competition from the lighter (and therefore pleasanter) and more glamorous new industries.

The report does not accept the view that the quality of graduates is falling, now that the sources of recruitment to engineering training are drying up. These are the apparent results of the much greater demand; but there is still a substantial reservoir of untapped talent in those who at present leave school at 16, especially if the prestige of an engineering career were to be raised in the grammar and public schools.

Two opinions are, however, almost universally held by industrialists. The first is the need for a high proportion of professionally trained engineers entering industry to have had some practical experience before or during their academic education. Hence the growing popularity of sandwich courses and the opposition to post-graduate research work which postpones entry into industry. The other is the difficulty of finding men with the qualities of personality and character, as well as of technological prowess, from whom to recruit future industrial leaders. This may well be another aspect of the problem of pursuading more able boys from the grammar and public schools to become engineers; but it also emphasises the need for a broader based university educational curriculum for engineers, so that they can be helped as far as possible to develop these qualities. In that case the need for post-graduate instruction in special technologies will become much more important.

There remains a suspicion that some of our older and traditional industries, as well as some of the newer ones, still largely controlled by the generation of practical men who founded them, are insufficiently aware of the need for professional engineers or engineer-scientists if they are to maintain their competitive positions in the world. The engineer in industry must understand, before he can apply, the radical new scientific discoveries which are taking place at the universities as well as in the laboratories of industry and of Government.

Other industrialised countries are up against similar difficulties. In this country we shall succeed in overcoming them only if teachers and engineers, in the schools, in universities and in industry, are sufficiently flexible in outlook to understand conditions that are changing rapidly. Fundamental changes—such as the increasing proportion of school-leavers who are needed as scientists and engineers—have taken place, and are taking place, in as little as ten years. But unfortunately, in the outlook of the individual teacher or engineer, the time span of a generation may have to pass before a fundamental change in outlook takes place. This is not nearly quick enough. Some good is bound to come from the frequent discussion of shortages, but more important is the cultivation of flexibility in outlook and imagination among those who educate and employ young people. Old assumptions, accepted practices and traditional opinions are in need of constant questioning. This should not be a difficult exercise for teachers and engineers.

* *Report on the Recruitment of Scientists and Engineers by the Engineering Industry.* H.M. Stationery Office. (1*s.* 3*d.*)

Weekly Survey

Cover Picture: *Lowering into position on the bedplates the first housing of the breakdown mill for a combined universal beam and heavy-section rolling mill now being built on the North East Coast. The building will be* 3,000 *ft. long, and the designed annual output of the mill is* 400,000 *tons of rolled material.*

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A Fourth Continuous Strip Mill ?

One of the fruits of denationalisation of steel is the freedom of individual companies to speak about their plans. The Steel Company of Wales did so last week to the *Financial Times* when they gave details of the third stage in their development programme and said that industry-wide discussions, which have been going on for over a year on various proposals for building a fourth continuous wide strip mill, have now reached an advanced stage. The approval of the Steel Board required under the Iron and Steel Act, 1953, has not yet been given, however, and the scheme may not be officially considered for two to three months. But the Steel Company are hardly likely to have made the statement unless the industry and the Government looked upon the suggestion in a more favourable light than a year ago.

A new continuous strip mill would involve major additions to iron and steel making capacity, and would vastly increase the country's requirements for iron-ore imports and ore-carrying ships as well as entail extensions to port and transport facilities. It could, however, be an opportunity to use lower grade ores (if the necessary ore concentration plant was obtainable in time) and eventually to close down uneconomic mills now used as marginal capacity. A project of this kind creates a host of difficulties, but it is also a *sine qua non* of British industrial expansion. Unless the steel industry keeps ahead of demand, the engineering industries will run the risk of being elbowed out of the race for export markets. Unless there is enough steel there will be dollar imports (which may dry up at any time), and inflation in one vital sector of our economy. The risk that we might have too much capacity need not deter the industry any more than it has deterred the American industry since the war. Every industrial concern has to face this risk at some time in its growth and those who do not accept it are in effect withdrawing from the race. The country cannot afford the steel industry to do so.

Meanwhile the Steel Company of Wales are going on with the second and third stages of their approved development programme. The £40 million second stage, which ends next year, will raise sheet capacity by 190,000 tons and tinplate capacity by 375,000 tons. The third stage may raise output of hot rolled coil by a further 500,000 tons. Such announcements are a tonic to industry; why therefore should the Steel Board keep everything to itself until it has been approved?

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Productivity under Pressure

A review on high-pressure die casting has now been published by the British Productivity Council, setting out how far the recommendations of the team that visited the U.S.A. in 1951 under the auspices of the Anglo-American Productivity Council have been carried out. It finds that although improvement is evident in many directions, much still needs to be done. The motor-vehicle manufacturers take 60 per cent. of the industry's products so the pressure die casting industry has shared in the recent expansion of motor industry and could well continue to do so. This dependence, of course, could be dangerous and there is clearly an incentive to broaden the industry's outlets.

The 1951 team condemned old and unsuitable buildings and advocated greater standardisation of products together with a greater co-operation between manufacturers and customers. The use of work study to increase efficiency, especially the scope for mechanical handling equipment as a step toward increased automation, was particularly emphasised. The latest report shows that while attention to production techniques has been prominent in nearly all concerns, and that wider use of mechanical handling equipment in particular has made an important contribution towards this trend, there is still a lot of room for extending the application of management techniques. Specifically, the report mentions the need for more accurate systems of costing, work study and planned maintenance schemes. With the rise in costs of both labour and materials, this need has increased still further. In the year to November, 1955, the price of zinc—the principal metal used in pressure die casting—has risen by 12 per cent., while aluminium is 10 per cent. above last year's level. There is therefore every incentive to reduce internal costs, over which management has control, by improving production and management techniques. The important question is how soon will progress on all fronts measure up to the opportunity to expand—an opportunity which obscures an eventual need for diversity. Here is a worthwhile challenge to a young industry.

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Locomotive Booster

The placing of firm orders by the British Transport Commission for £10 million worth of rail traction equipment has given the private locomotive industry the biggest boost they have had for years. Traditionally an export industry, deprived of a stable home market by the railways' practice of building most of their own locomotives, they have argued at times with much bitterness that no industry could prosper under such conditions. Experience has proved they were right enough, and the change in the Railways' policy is to be welcomed.

Since the war there has been a radical change in the production policy of established steam locomotive builders. One of the largest, Vulcan Foundry Limited, have been acquired by English Electric, and the others have formed loose associations with the major electric machinery manufacturers for the joint building of electric, Diesel and Diesel-electric locomotives. Throughout the world, coal shortages or costs have led to a switch from steam to Diesel and this change has produced a well-knit and powerful British industry, which includes Diesel engine makers, to meet the changed demand. The B.T.C. orders now give this industry the opportunity to see their products operating over long periods on home railways.

It should be noted, however, that the Commission have issued a caveat: their future policy for the manufacture and repair of Diesel and electric locomotives is "actively under review," but these orders on private builders, "being pilot models for trial purposes, should not be taken as an indication of permanent policy." There is certainly the major consideration of the future of the large railway workshops in this country, where 37,500 are employed and where repairs and new work are done. The opportunity to depart from established practice in drawing on private industry for major requirements should not be lightly dismissed; the alternative—large scale re-equipment of railway workshops and the recruitment of electrical and Diesel engineers and designers—is not one which commends itself at this stage of the country's economic development.

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White Man's Burden—New Version

The sale of arms by the Soviet bloc to Egypt has upset the political balance of power in the Middle East. There is every indication that Russia is equally busy changing the economic balance of power. The antics of leading communist statesmen in India over the last week or so make it abundantly clear that they are anxious to trade with South East Asia on highly favourable terms to that area. This kind of economic penetration has, of course, been going on for some time but it is now clear that a situation has developed in which the Western Powers and the Soviet bloc will try to outbid each other in the economic development of the East. Whatever else may happen one effect is likely to be a much more rapid rate of development of agriculture and industry in that area than seemed likely a few years ago.

The haste with which the World Bank examined the possibility of finding finance for Egypt's Aswan Dam project after the offer of Soviet arms to that country was published, was a straw in the wind. It will be surprising if there is not a noticeable increase in the number of offers, great and small, for help in developing the Orient from the two great political blocs from now on. The Soviet bloc has offered attractive terms to India in such matters as the sale of coal, erection of steel mills and development of atomic energy. Atomic energy was mentioned by the delegates to the meeting of the Baghdad Pact last week, at which the British Foreign Secretary was present; the United States has arranged for permanent economic liaison with this group. The offer by the Republic Steel Corporation in the United States to make available technical and manufacturing expertise abroad through its newly-established International Projects Division shows the way in which industry may follow the flag in these matters.

This country has already shown enterprise when faced with competition in the East which has a strong political flavour. Its recent success in getting one of the big Indian steel contracts against German and Russian competition is a case in point, and the announcement last week that Associated Electrical Industries Limited has gained the appointment as consultant to the Indian Government for a £20 million project to establish a heavy electrical industry in India is a more recent example of the fact that British competition in this field has got teeth.

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Future for Copper

To judge from recent annual reports issued by the principal Rhodesian copper companies, the outlook for copper is bright—in a feverish sort of way. Copper is still scarce, and Sir Ernest Oppenheimer, chairman of Rhodesian Anglo-American Limited, suggests that any increase in production in the near future will be easily absorbed. It is in the long term that the fears of the Rhodesian companies lie, and this fact is the more significant because the Rhodesian copper mines were before the war among the lowest cost producers in the world.

The price of copper has fluctuated alarmingly over the past year. Having touched £400 per ton in September, 1955, it reacted gradually to £290 and towards the end of November it again hardened to around £380 per ton. The main cause of these price fluctuations has been the irregularity of supplies, for which there are two main reasons. First the U.S. Government pursues a fickle policy in taking up or releasing copper at any time from its stockpile; second—and this is the factor which has mainly bedevilled the world copper industry over the last year—which will be the next copper producer to have labour trouble? Strikes in Chile and the U.S. early in the year occurred at the same time as a two-months' strike of African workers in the Rhodesian copper belt. The Chilean and U.S. strikers are blamed for the sharp upswing in prices this year, and in fact it is suggested in some quarters that were it not for strikes, supply could satisfy the present heavy demand at a more realistic price.

In the short run, the reaction to high prices may not be severe, because many who are sensitive to copper prices and can quickly find a substitute have already taken action. In the long term, high prices may permanently harm

the world demand for copper. The chairmen of both the copper mining groups in Rhodesia mention the dangers inherent in intensifying competition from substitutes. Clearly the elimination of fluctuating, and at times excessively high, prices depends upon a less volatile demand for stockpiling, an even flow of production and a steady development programme. So far as supply is concerned (and this is the only side which the companies can control) the outlook is improving. The proposed Kariba hydro-electric scheme, scheduled to be completed by 1960, the importation of electricity from the Congo in 1957, and better transport facilities aided by a £5 million purchase of trucks for the transportation of coal and ore by the Rho-Anglo group, should make fuel supplies adequate, while the recent labour agreements on the status of the African worker should help to avert further strikes.

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Synthetic Rubber Consortium

Those who have taken a conservative view in this country of the desirability of manufacturing synthetic rubber here on a large scale have based their case on two main arguments. They have said that commercial-scale production in this country must await an assured supply of raw materials and a modicum of experience in the production process. They have emphasised the problem of developing new techniques which would not be able to use the traditional skill employed in processing latex from natural rubber. Now that the supply of styrene and butadiene from the much-expanded British oil industry has become assured, the raw materials argument has lost its force. Pilot plants making synthetic rubber have now provided the modicum of experience on which to build, thus weakening the second argument.

A £7 million project to make synthetic rubbers in the United Kingdom has now been announced by the big tyre companies. These are Dunlop Rubber Company, Limited, Goodyear Tyre and Rubber Company (Great Britain), Limited, Firestone Tyre and Rubber, Limited, and Michelin Tyre Company, Limited. These four sponsoring companies are establishing the International Synthetic Rubber Company for this purpose and other tyre makers are being invited to take part. The initial production is tentatively put at 50,000 tons of G.R-S (general rubber-substitute) a year as from 1958, compared with the current annual rate of consumption by the U.K. tyre industry of 150,000 tons of natural rubber. The Dunlop Rubber Company and Monsanto Chemicals Limited announced last year that they would build plants to make synthetic rubbers but these have quite small capacities. Large-scale plants have been awaiting an adequate flow of materials and this will be forthcoming when Imperial Chemical Industries, Limited, and British Petroleum Chemicals, Limited, begin to produce butadiene at Grangemouth in Scotland next year. A major expansion in the supply of styrene monomer is scheduled at Forth Chemicals, Limited, also at Grangemouth, for early in 1956. (Forth Chemicals is owned by British Petroleum Chemicals and Monsanto Chemicals.) At present the U.K. rubber industry imports about 10,000 tons a year of G.R-S rubber but has been given permission to import 50,000 tons in 1956.

The British rubber industry is thus about to take on the production of a synthetic which it had considered for many years to be a deadly rival of the natural product on which the rubber industry had been established and had thrived. The move, however, is obviously right.

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Preserving Cornish Engines

This country, the birthplace of the Industrial Revolution, has lost so much in the past through failure to appreciate that engineering relics can not only give pleasure to, but also instruct, engineers at present and in the future, that the preservation of typical examples of what is left has become a matter of urgency. Engineering relics can be preserved in one of two ways: they can, where practicable, be placed in a museum, or they can be maintained *in situ*. Those who have seen something of the ancient monuments in the care of the Ministry of Works will know how successful this *in situ* preservation can be, given the necessary finance and expert attention. There are many who would like to see some of our engineering relics, which are too large to be taken into a museum, pass into the care of this Ministry, and so become a national responsibility, but under present economic conditions such a development is most unlikely. Meanwhile, voluntary bodies are doing good work in the face of many difficulties.

Such a body is the Cornish Engines Preservation Society. This small society, which originated as a committee in 1935, to save a Cornish winding engine from destruction, now has in its care several typical examples of Cornish winding and pumping engines. The stopping of Robinson's 80 in. pumping engine, the last to work at a Cornish mine, to which reference is made elsewhere in this issue, focusses attention on the Society's work. The mining company have announced their intention of presenting the engine to the Society, probably in the near future, and as it is a particularly interesting one it will be accepted gratefully. The problem of preserving it will then have to be faced. With the engine idle, corrosion, wind and weather, and even vandalism all take their toll, as the Society well know from their experience with other engines.

The technical difficulties of preservation, though considerable, can be solved. It is the financial problems which are more pressing. Mr. W. Tregoning Hooper, St. Anthony Cottage, St. Agnes, Cornwall, the hon. secretary of the Society, said in his annual report recently that the Society had done all that they set out to do in the matter of putting their property in good order. They had had generous assistance from certain individuals and firms, notably Holman Brothers, Limited, Camborne, who had re-conditioned the Society's beam winding engine at East Pool at their own expense and have placed another engine on permanent exhibition in their works museum at Camborne.

The Society now own a number of engines, most of which could easily be made accessible to the public, and they are in first-class condition. Whether or not they can be so maintained depends upon the support which the Society receives. The good work is worthy of support from the British engineering industry.

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Hand and Machine in the Country

Under this title comes the annual report of the Rural Industries Bureau for 1954–55. Founded in 1921, the Bureau had last year a grant from the Treasury of £112,454 to advise and help rural industries and crafts. Dealing as it does with the industries of the countryside, it has, nevertheless, had to face the facts of modern economic life, and realising the competitive strength which large undertakings derive from advancing techniques it has been concerned to adapt them to small independent users. In the future the Bureau envisages a systematic development of its advisory services in technique and business management.

The scope of its activities cover a wide field, including blacksmithing and agricultural engineering, woodworking, clay industries, saddlery, thatching, textiles and boat building. The mechanisation of agriculture is spelling the death of one-man blacksmith's shops, their modern equivalent being the concern employing three to a dozen employees in a well equipped workshop.

The gradual transformation of the traditional blacksmith-farrier-fitters into agricultural engineers relying less and less on the fire and the anvil has not meant the complete elimination of the old-time craftsman. When he has strong leanings towards forge-craft, he has turned to some extent away from mechanical matters in order to develop his manual dexterity and feeling for decorative ironwork. There has been a marked revival of interest in this work and a gradual increase in demand for its products. Apart from the production of small articles, such as hearth furniture, some rural smiths are now undertaking commissioned work for ecclesiastical and public bodies. An example is the two very large pairs of gates for Ascot racecourse being made by a village smith in Oxfordshire.

An experimental boat is being built in which glue and laminated techniques are being used as far as possible in the construction of the hull. The object is to explore the possibility of using Admiralty-approved resins in the small boat-building yard to save time and so learn what economies can be effected in the use of timber, to avoid the manufacture of costly jigs and in other ways assist the small-boat builder. Records are being kept so that comparisons can be made between the assembly of a conventional hull and a laminated hull of the same design. So far the laminated hull appears to show considerable savings.

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The Ferguson Project

The secrecy which surrounds the Ferguson vehicle project continues to produce a flow of speculations and rumours. There is no immediate intention of marketing any car, still less a people's car, but rather of making available a set of patents on suspension, steering transmission and braking, applicable to a wide range of two and four wheel drive vehicles.

In its original form, as conceived by Mr. F. W. Dixon, the car consisted of a tubular backbone of 6 in. diameter, to which were attached four independently sprung and driven wheels. The engine, which was a Jowett Javelin "flat-four" for some time, could be mounted with the gearbox at either end of the vehicle, according to the particular application envisaged. The main transmission shaft was carried inside the tube, and at each end of the tube was a multi-plate disc brake, like a multi-plate friction clutch. It acted on an extension of the worm shaft in the final drive, and so through the differential on the adjacent wheels. The method of gear selection and the differential were also the subjects of patent protection.

Suspension at front and rear was by swinging half axles, with low pivots below the axes of the drive shafts, to lower the roll centre and keep wheel camber within acceptable limits. For steering, the whole of the front swing axles swung about the joints where they were attached to the chassis tube, so that there were considerable variations in track, and it is understood this feature was abandoned. The problem of the differential between front and rear wheels, necessary to permit different speeds of rotation on corners, and also to compensate for differences in rolling radius due to tyre wear or uneven loading, is the subject of a later patent by the present chief designer, Mr. Claude Hill. This is a combination of gears and a roller-type free wheel, designed to obviate a situation where loss of traction on one wheel could prevent the vehicle moving.

It is believed that considerable progress has been made with a transmission which combines gears with a fluid torque converter, but stories of a central pump supplying oil under pressure to separate turbines which drive each wheel, or with reversed fluid flow to act as a brake and ultimately drive in reverse, are wide of the mark. Many attempts have been made to obtain acceptable efficiency from such a system; the latest was a Dutch car shown at the Paris salon in 1953, for which 67–74 per cent. transmission efficiency was claimed, but so far as can be ascertained it does not figure among Mr. Ferguson's immediate activities. Work has, however, been initiated on a hydraulic suspension system, with interconnection between front and rear.

THE RESURRECTION OF ICARUS

Can a man fly by the power of his own muscles? Mr. B. S. Shenstone, chief engineer of British European Airways, answered this question with a qualified affirmative in a paper on "The Problem of the Very Light-weight, Highly-Efficient Aeroplane," which he read to the Low Speed Aerodynamic Research Association recently.

Some 20 years ago, when the first scientific attempts to fly by human muscle power were made, the answer would have been in the negative, because the inventors did not apply to their machines the aerodynamic improvements which are now known to be possible. Since then, as Mr. Shenstone pointed out, attention has been given to powered flight under the most competitive conditions, not the most economical ones, because people can afford to pay for speed. In fact, the process has been going on since powered flight first began on December 17, 1903; 12 h.p. was then the minimum with which a man could fly, and "in 50-odd years this power has become less, but more is always used."

The design of man-powered aircraft was stimulated when a contest for such machines was announced in Germany in 1933, and four types which were produced shortly afterwards were mentioned by Mr. Shenstone: the Bossi-Bonomi in Italy, the Haessler-Villinger and the Seehase in Germany, and an unnamed Russian design. All were more lightly built than any modern sailplane and would have needed much less power to maintain height; in fact, the "Windspiel," one of the lightest sailplanes ever built, would have required as much as 1·3 h.p., and the "Minimoa," a standard pre-war sailplane of large span, would need 3 h.p. Otto Lilienthal's primitive glider of the 1890's, although lighter still, would have needed 1 h.p. to sustain itself because of its bad aerodynamics.

The Haessler-Villinger appeared the most attractive of these muscle-power machines, so Mr. Shenstone took this design as a basis and showed how it could be improved on modern aerodynamic principles to the point at which a man could maintain it in the air by his own efforts. In its original form this machine, with an empty weight of 77 lb. and a pilot weighing 165 lb., would need 0·82 h.p. to keep it flying at a speed of 30 m.p.h. A human pilot can only maintain this power for a very short time, and although Mr. Shenstone did not mention it in his lecture, the longest flight made in the Haessler-Villinger during a series of trials in 1935 was in fact one of 24 seconds, covering 257 yards.

Among the methods of improving performance, first of all comes drag reduction. Very little has been done on this subject in the last 20 years except for some recent work by Dr. August Raspet, of Mississippi State College, on sailplanes. By making the surfaces as smooth as possible, eliminating interference between them, removing protuberances and getting rid of leaks, Raspet has been able to obtain a minimum drag coefficient of only 0·01 on a sailplane of 40·3 ft. span called the "Tiny Mite." The process is laborious and time-consuming, but by applying it to the Haessler-Villinger, Mr. Shenstone estimated that the horsepower required for flying could be reduced from 0·82 to 0·68.

Next, by flying the machine close to the ground, say at 10 ft., there would be a reduction of induced drag—the drag resulting from the production of lift—and the power required at 30 m.p.h. would be brought down to 0·58 h.p. The next method available is boundary-layer suction; if applied so as to produce laminar flow over the whole wing, another 0·2 h.p. could be saved, thus bringing the power needed to only 0·38 h.p., but the effort required to produce the suction would absorb 0·1 h.p.

So much for aerodynamics. The next improvement possible is a reduction of weight. Nothing can be done about the pilot, but even modern gliders are a good deal heavier than they need be, because weight-reducing refinements are expensive. The Seehase, already mentioned, had magnesium-alloy tubes for spars and only four ribs per side, with doped silk for the wing surface. If we can halve the sort of structure weight so far considered, of the order of 75 lb., the gross weight could be reduced to 203 lb. and another 0·06 h.p. could be saved.

Back to aerodynamics again, there comes the possibility of bringing down the induced drag still further by increasing the span from 44·3 ft. (that of the Haessler-Villinger) to 60 ft. Although this would mean increasing the weight by 53 lb., Mr. Shenstone concluded from an elaborate series of calculations that there would still be an overall advantage resulting in a saving of about 0·05 h.p.

The power would be applied by a propeller, which would also pump out air sucked from the wings through its hollow blades. Allowing for an efficiency of 75 per cent. for the drive and the propeller, Mr. Shenstone's final conclusion was that 0·6 h.p. would be required to sustain the Haessler-Villinger at 30 m.p.h. after all these improvements had been applied to it.

A man can certainly exert this power for a short time, but can he do so indefinitely? Data on human muscle power were collected and published in Germany in 1936 and 1937. From these figures it is apparent that a trained athlete can produce 0·6 h.p. with his leg muscles alone for only 50 seconds; i.e., he could fly about half a mile. But by using both his arms and legs together, he could raise 0·6 h.p. indefinitely. However, he would have no limbs free for controlling the machine, so Mr. Shenstone's final proposal was for a two-seater with an all-up weight of 185 lb. This would require 1 h.p., or 0·5 h.p. per man; but in practice one man, the "galley slave," would use both arms and legs to produce 0·6 h.p., while the pilot would control the machine with his hands and push with his legs alone. In fact, even with a propulsive efficiency of only 60 per cent., the hard-worked pair could still keep flying.

END OF AN ERA IN MINE DRAINAGE

THE LAST CORNISH ENGINE TO WORK AT A CORNISH MINE

By John H. Trounson, A.C.S.M., A.M.I.M.M.*

With the withdrawal from service of Robinson's engine at South Crofty Mine, Redruth, Cornwall, on May 1, 1955, the long and honourable career of the Cornish engine in the area of its origin may be said to be virtually at an end. One or two relatively small engines are still at work at Cornish china clay pits, but in underground mining, for which the Cornish engine was developed, not a single one remains in use. Robinson's engine, which has an 80 in. diameter cylinder with a nominal stroke of 10 ft. 4 in., remains *in situ*, but it will not be used again. It has been superseded by electric pumping plant, partly because it was too costly to operate with coal at present-day prices, and partly because mining developments are making it necessary to raise a greater quantity of water than the engine will handle.

This is not the place to speak of the history of the Cornish engine in general. A considerable amount of information exists on the subject, and it was summarised in ENGINEERING, vol. 176, page 339, 1953. Something may, however, be said of Robinson's engine itself, for it has had an interesting history and its story is in many ways typical of a number of other Cornish engines which no longer exist. The Cornish engine was a large and valuable piece of capital equipment, and as such it often changed hands in a manner which may seem surprising when it is considered how primitive the transport and handling methods were at the time. Cases are on record

* Honorary curator, Cornish Engines Preservation Society, Redruth.

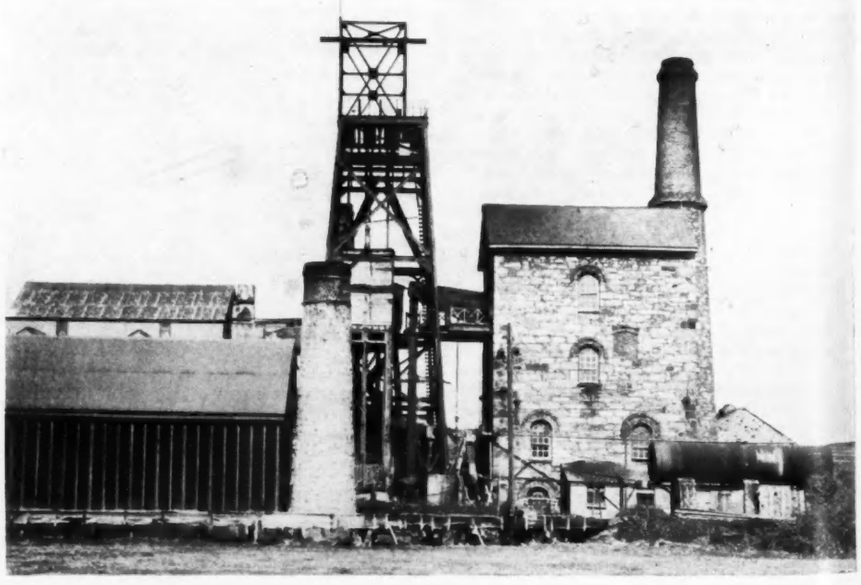

Fig. 1 The last Cornish engine to work at a Cornish mine—Robinson's 80 in. engine. The engine house, with its boiler stack at the corner, is typical of Cornish practice.

of Cornish engines being erected at a Cornish mine, working there for a time, then being taken as far away as South Wales, and finally returning to Cornwall, where they gave service for many more years.

MOVEMENT FROM SITE TO SITE

The travels of Robinson's engine were not so extensive; nevertheless it was moved several times. The engine first appears in the records on July 19, 1854, when J. Pool, works manager of Sandys, Vivian and Company, Copperhouse, near Hayle, Cornwall, wrote to Samuel Grose, saying " Our price for an 80 in. pumping engine, 10 ft. stroke, equal beam, and of usual construction, would be without boilers about £2,700, and with 2 boilers, each 12 tons with boiler fittings, about £3,400."* The engine was built to the design of Samuel Grose (1791–1865), a pupil of Richard Trevithick, and incorporated some unusual features.

The first user was the Alfred Consols Mine, at Gwinear, near Hayle, where the engine was installed probably in 1854. Little is known of its early days, but in January to March, 1863, it was reported† as doing a " duty " of 74 to 77 millions, the " duty " being the number of pounds of water raised 1 ft. high for the consumption of one bushel of coal. The engine was then known as Davey's engine, being named, in accordance with Cornish custom, after the shaft at which it was installed. In this, its first working, the engine drew water from 142 fathoms with 16 in. pitwork, and ran at 5½ to 6½ strokes a minute.

Alfred Consols Mine ceased work about 1864, and the engine is next heard of at Crenver and Wheal Abraham Mines, Crowan, not far from where it was originally installed. Here it was known as Pelly's engine. It drew from 262 fathoms in a crooked and partly-inclined shaft, with pitwork varying from 16 in. near the surface to 10 in. at the shaft bottom. Working under these conditions it gave a duty of 53 to 70 millions.

The engine's next move was also over a short distance, to Tregurtha Downs Mine, where it worked from about 1882 to 1897. Here it changed its name again, becoming the St. Aubyn engine, and drew water from 125 fathoms with 20 in. pitwork, giving a maximum duty of 68 millions at 8½ strokes a minute. Incidentally, during the time it was at this mine, the engine was sometimes run at the almost unprecedented speed of 13 strokes a minute. A fire in the engine house in 1889 damaged the engine severely, but it was repaired and put to work again.

A MOVE OF 15 MILES

The final move came in 1902, when Nicholas Trestrail, consulting engineer to South Crofty Mine, exercised an option to purchase the engine for £375.‡ This being settled, it remained to dismantle the engine at Tregurtha, transport it about 15 miles to its new site, build a house for it, install it and provide the necessary pitwork. A tender was received for dismantling and transport for the sum of £125, but it is not recorded if this offer was accepted. In the case of the house, however, more details have survived. A contract was signed on March 9, 1903, between John and William Gay, builders, of Tuckingmill, Camborne, and John Penhall, the mine manager, for the erection of the engine and boiler houses, complete with chimney stack and foundations or " loadings " as they are always called in Cornwall. The builders undertook to carry out the work for 12s. 6d. per perch, the total sum involved being £1,122. The building, (Fig. 1), is a typical example of the traditional Cornish engine house. It is of local stone, with the stack built on to one corner. Only the top one-third of the stack is of brick, stone being cheap and bricks expensive in Cornwall.

The contract, which still exists§, contains a clause permitting the builders to take down and use as building stone three old engine houses on the mine property, provides that the cylinder " loading " shall be of granite blocks (in accordance with Cornish custom), and allows the mine management to discharge any workmen " . . . whom they may consider incompetent, or for using profane language or misconduct." The work was to be completed in 18 weeks from the date of the foundations being ready, with a penalty of £5 per week for exceeding this period.

While the business of getting the house built was being settled, tenders were sought for the boilers and pitwork, and in due course these items were ordered. Two Cornish boilers, of a size which is unrecorded, were obtained from Holman Brothers, Camborne, at a cost of £596, and the pitwork was supplied by Harvey and Company, Limited, Hayle, for £1,070.*

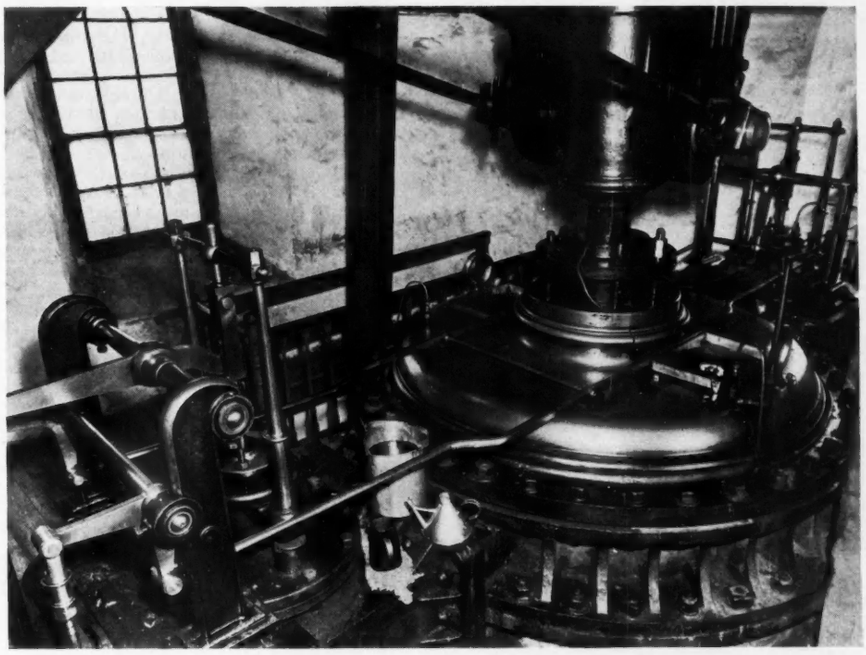

Fig. 2 Robinson's engine has an unusual arrangement of steam and equilibrium valves, which are placed diametrically opposite, so anticipating to some extent the design of the uniflow engine.

PITWORK AND PUMPS

A copy of the specification for the pitwork, prepared by Nicholas Trestrail, exists, but the drawings referred to in the specification do not appear to have survived. It is particularly unfortunate that these drawings have not been preserved, for the pitwork is an essential part of any Cornish pumping installation, and there is very little on record of this equipment. Drawings also existed at one time of the pitwork at New Cook's shaft, South Crofty Mine; these too, have disappeared, but photographs of them exist† and as they were typical of general practice, Fig. 3 has been prepared from them. These drawings, and those reproduced in Fig. 4, were the work of the late Arthur Jory, formerly the shaftman at South Crofty.

The simplest form of pitwork is a bucket pump at the bottom of the shaft, connected to the engine beam or " bob " by a wooden rod. Pitwork of this type sufficed while the mines were shallow, but as depths increased the water was lifted in stages, with a bucket or plunger pump in the shaft sump, which lifted to a cistern in the shaft, and a series of plunger pumps above it, each lifting to the one above, until the adit or surface was reached. All these pumps were connected to the engine by a wooden rod (the " main rod ") which, at the top of the shaft, may have been 20 in. or more square. The load on the rod decreased as successive pumps were passed, and the pump rod was accordingly reduced in size.

Each pump was carried on heavy timbers or girders in the shaft, the actual plunger or " pole " being offset from the main rod. Several feet above the pump the plunger was connected to the main rod by means of a timber spacer and wrought-iron strappings. This can be seen on the left of Fig. 3. The plunger centre was of wood, rounded to fit into the cast-iron pole " shell." The " stocking " or fitting of the timber into the iron shell was done at the surface, by lying the shell and the rounded rod horizontally and driving the rod into the shell. It required considerable skill to fit the timber tightly into the cast shell without splitting it, and was an art which is now almost extinct.

The arrangement shown in Fig. 3 was applicable to a vertical shaft. When the shaft was not vertical, modifications were necessary. In the case of a straight inclined or " underlie " shaft the pump rods could rest on rollers fixed to beams or timbers in the shaft. Sometimes, however, the shaft had several bends, and may have reversed its direction more than once before the lowest pump was reached. A crooked shaft, like that at Crenver and Wheal Abraham, where Robinson's engine once worked, required means for passing the rod round each of the bends, or " breaking the angle." Five methods of doing this are shown in Fig. 4.

EIGHT LIFTS OF PUMPS

Robinson's engine, in the form in which it ceased work, and in which it still remains, worked eight lifts of pumps in the shaft, excluding a small auxiliary pole 7 in. in diameter at the 24 fathom level discharging into the adit. The main pumps are: one 10 in. pole at the 335 fathom level, discharging at the 290 fathom level, a vertical distance of 267 ft.; six 14 in. poles from 290 fathoms to 36 fathoms, a total vertical distance of 1,370 ft.; and one 15 in. pole at 36 fathoms, discharging to a launder 12 ft. above the surface, a lift of 396 ft. The total lift from the bottom of the shaft to the launder at the top is 2,033 ft.

Balance beams or " bobs " are used at the surface and in three places underground, to balance the major part of the weight of the pump rods, the remaining weight being used to do the actual lifting of the water on the down or

* Sandys, Vivian letter books. In possession of Mr. T. Harris, Camborne.
† Lean's Engine Reporter.
‡ Letters in possession of South Crofty, Limited.
§ In possession of South Crofty, Limited.

* Letters from suppliers to South Crofty Mine acknowledging acceptance of tenders. In possession of South Crofty, Limited.
† In the possession of the writer.

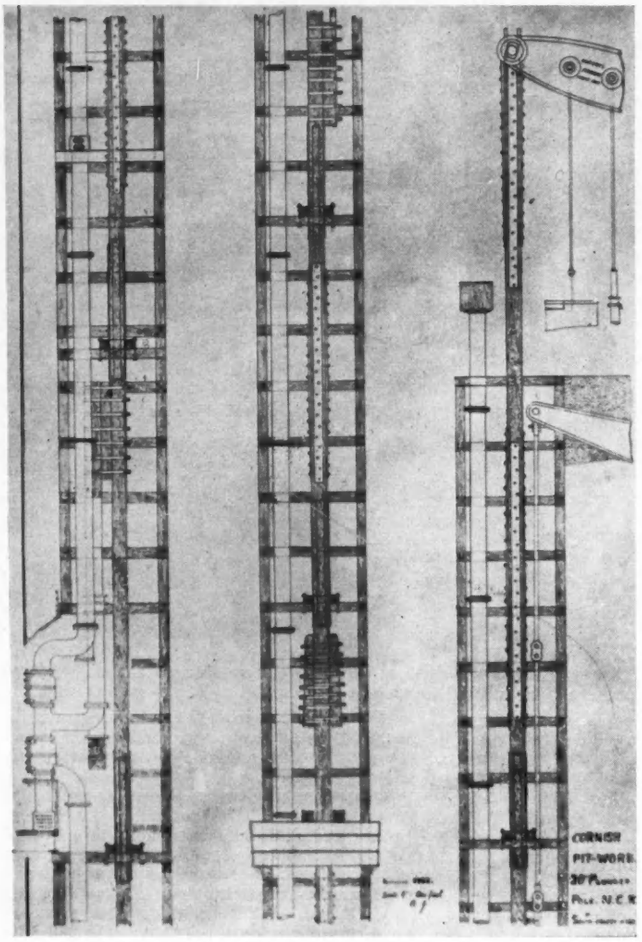

Fig. 3 The engine was connected to the underground pumps by wooden pitwork. The surplus weight of the pump rods was balanced by weighted beams or "bobs" at the surface and underground. "Catch wings" were installed at intervals to hold the rods in case of breakage.

"outdoor" stroke of the pumps. The only work done by the engine, which is single-acting, was in the lifting of the rods on the up or "indoor" pump stroke. A simple calculation based on the height and diameter of the water column in the shaft shows that the weight of water in motion at each stroke was 59·3 tons; to this should be added 10 per cent. unbalanced weight which was necessary for overcoming mechanical and water friction. This means that the total load lifted by the nose of the engine "bob" was about 65 tons. The engine has an "even" or equal-armed beam, and the water load per square inch of piston area was 26·4 lb.

OPERATING PERFORMANCE

Running at 4·5 strokes per minute and with an actual stroke, due to wear and tear, of 9 ft. (against the nominal designed stroke of 10 ft. 4 in.) the engine consumed about 55 tons of coal a week, giving a "duty" of 49,299,433 ft.-lb. of work done per 112 lb. of coal consumed. The engine exhibits several interesting features, notably in the steam-distribution arrangements. Normal practice with Cornish engine designers was to place the steam-distribution valves all on the same side of the cylinder and connected to a single portway. A certain amount of heat loss from live steam to surfaces cooled by the spent equilibrium steam on its way to the underside of the piston was therefore inevitable. Grose attempted to reduce this heat loss by placing his steam and equilibrium valves diametrically opposite, that is, as far apart as possible (Fig. 2). In so doing he anticipated to some extent the principle of the uniflow engine. Temperature measurements taken on Robinson's engine under normal working conditions showed that Grose's plan was sound. The steam portway or "aperture" in the cylinder had a temperature of 241 deg. F., while the equilibrium aperture was at 224 deg. F. The design thus protected the hot live steam to some extent from contact with a surface having a temperature 17 deg. F. lower.

The directors of South Crofty, Limited, have announced their intention of presenting Robinson's engine to the Cornish Engines Preservation Society in the near future, and it is hoped that it will be possible to maintain it in its present condition as a monument to its ingenious designer, and to the first-class workmanship which enabled it to operate successfully for a century. Whether or not that can be done depends upon the support which the Society receives.

(*Editorial comment in Weekly Survey*)

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FORCED DRAUGHT SYSTEM IN STEAM BOILERS

History of James Howden and Company, Limited

In the year 1854, a talented young man, James Howden, set up in business on his own as a consulting engineer; he was then 22. Due to his skill and energy and that of his successors, the firm, now known as James Howden and Company, Limited, Glasgow, has grown steadily for the last 101 years. An account of the firm's history from 1854 to 1954 has been written by the present chairman, Mr. Crawford W. Hume.

James Howden began by designing machine tools, but was soon attracted to the design of boilers and main engines for steamships. After a few years of working through contractors he decided it would be better to make his own designs, and in 1862 he set up the firm known as James Howden and Company, Engineers, Millwrights and Boilermakers. After much experience in designing and making the propelling machinery for ships, Howden proposed in 1882 the system of forced draught which so greatly increased the efficiency of marine steam machinery.

In the early 1890's Howden found that because he sold the forced draught system to other makers of marine machinery he was in competition with his customers, and he therefore decided to concentrate on manufacturing the forced draught system alone.

During the slump soon after the war the company was fortunate enough to be asked to develop the Ljungström air pre-heater, which was subsequently used for both land and marine installations. In the fluctuating economic conditions since 1918, the Howden firm have continued fitting forced and induced draught systems, dust collectors and air preheaters in steamships and power stations. The story of their first hundred years is told in an attractive booklet, "A Hundred Years of Howden Engineering."

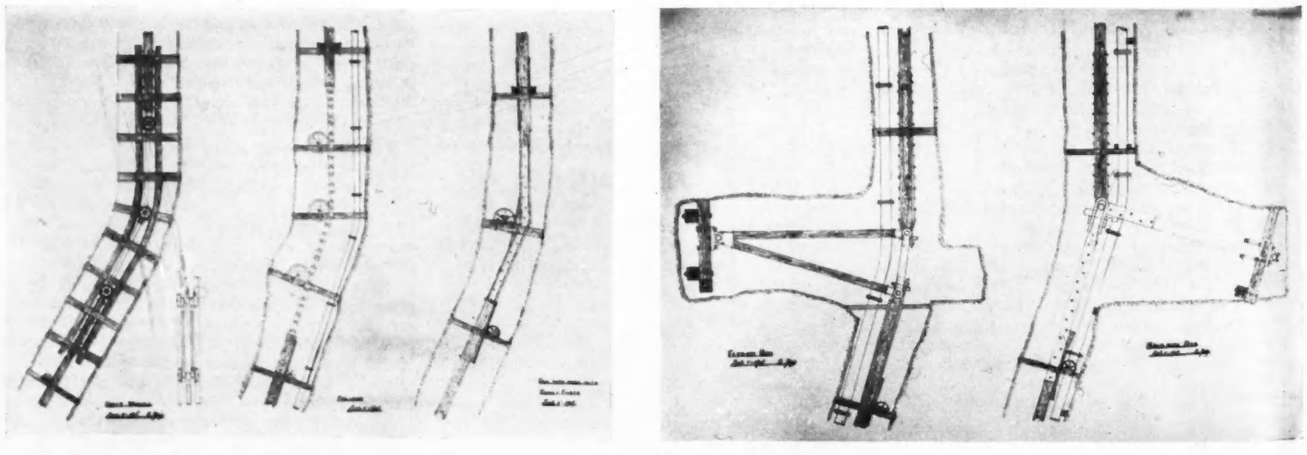

Fig. 4 Shafts were not always straight, and various means were employed to pass the pump rods round the bends. Five methods are shown here. These drawings, and that in Fig. 3, were the work of the late Arthur Jory, the shaftsman at South Crofty.

Letters to the Editor

PROVISION OF TECHNICAL LIBRARIES

What Manchester Does To-day

SIR, Your Weekly Survey note of October 28 says "a technical college serving a number of firms in the locality, as well as staff and students, fulfils a very useful function", and asks for "some information on running costs to set against a simple statistical analysis of the use made of the library in a year."

The library of the Manchester College of Technology costs about £6,400 a year for staff, books, periodicals and binding. Its primary purpose, of course, is to serve the 180 full-time teaching staff, 200 research students, 800 undergraduates, 200 other full-time students and those of the 500 part-time lecturers and 5,000 part-time students who wish to avail themselves of its services.

Local industry borrows about 500 books and periodicals a year, and other universities, colleges, Government departments and public libraries (often for firms in their areas), about another 300 items. Scientists, and others from local firms, make about 400 personal calls a year and the teaching staff often bring in industrial acquaintances, but no records are kept of these. About two-dozen telephone calls a week are received from firms and research associations. Nearly half of these are requests for the loan of some specific item and the others vary greatly from the simple "what is the periodicity of *Archiv für das Eisenhüttenwesen?*" or "where can a file of *Beton armé* be seen?" to the time-taking "information wanted, with bibliography, on submerged arc welding" or "a list of books wanted, on sand blasting of metals." Where does this catalogue take us? Not very far, I'm afraid. An analysis of use is not easy. The first query above was answered by reference to one volume; the second needed four or five references; the third more still, and the last, probably twenty. How are the four inquiries to be assessed?

It would be true to say, I think, that no college which does a fair amount of advanced work could hope to give a satisfactory library service with a total expenditure on staff, books, periodicals and binding of less than £5,000 a year. There are no signs as yet that local industry is prepared to make contributions large enough to pay for a good proportion of the cost of a college library. Is there any reason why industry should not pay £1 for £1 with the local authority to make college libraries more able to meet industrial demands? Or better still, could not D.S.I.R. show its concern and interest by going "thirds"? The nation needs the technologists and technicians, and to get them bold moves are necessary.

D.S.I.R. helped to set up the research associations some 25 years ago. They can be regarded as the defence in depth for industry. The local technical information service, whether it be in the public library or the technical college (or in both), could be regarded as defence outposts and I suggest that these outposts should be D.S.I.R's concern too.

There are already a number of cities where co-operation between the two technical libraries is strong and where active steps are taken to see that unnecessary overlapping does not occur. Even so, the field is so large that in the best of these areas self-sufficiency is hardly possible. (Even the London area borrowed 61 items from this college library in the last 12 months.) In the smaller towns many public libraries are offering technical information services greatly varying in effectiveness. The Advisory Council on Scientific Policy has suggested that they should be encouraged in this direction, but they can hardly expand enough without central financial help.

No college library can ever be as "free" as a public library. Its first loyalty will always be to its staff and students. In Manchester we have to refuse requests for the loan of journals such as *Proceedings of the Institute of Radio Engineers*, *Journal of the American Chemical Society*, *Transactions of the American Society of Mechanical Engineers*, *Chemical Abstracts* and *Berichte*. (Incidentally, the total subscription to these five titles is over £60.) And yet these are the kind of periodical wanted by industry. Some measure of duplication will always be necessary in any large industrial area, and no area has quite the same needs as any other.

There are many more questions to be answered before we can begin to plan a nation-wide technical and scientific information service. The more discussion we can get the better and I agree with your editorial that the time is ripe for a joint meeting of those most concerned.

Yours faithfully,

L. L. ARDERN,
Librarian.

College of Technology,
Manchester.
November 25, 1955.

SIR, The main function of this public technical library is to supply scientific and technical information to industry. It is housed in the Central Library building and contains 74,000 books, 450 current periodicals (the majority being filed and bound), over five million British, United States and Dominion patents, and 12,500 trade catalogues. In addition, there are extensive files of maps, clippings and standards, and a photo-copying service is provided.

During the period April, 1954, to March, 1955, 147,914 readers used the library, and 218,764 publications were issued. In addition to this, 5,913 readers used 21,460 patents, and 574 books were lent to firms all over the country; 477 books were lent to other libraries, 4,662 items were photo-copied for readers and industrial users, and many thousands of inquiries from firms, institutions and individuals were answered by telephone.

The total net expenditure on the technical library during this period, after allowing for an income totalling £137, was £6,691, the details being as follows: salaries £2,959, books £1,798, bookbinding £1,059, periodicals £797, printing and stationery £202, minor items £13. In addition to the above, to give a true figure, a portion of the total of £11,883 for rents, rates, etc., for the Central Building, would have to be added. This would bring the figure to about £9,000 for the year.

Yours faithfully,

M. O. DOBSON,
Technical Librarian.

Manchester Public Libraries,
Technical Library,
Manchester, 2.
November 26, 1955.

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SPIRAL-BEVEL GEAR-CUTTING MACHINES

SIR, The report of the British Gear Manufacturers Association meeting in ENGINEERING, on page 717 of the issue of November 25, is a reminder that although about 99 per cent. of the cars on the road have spiral bevel gears in their back axles there are no British spiral-bevel gear-cutting machines available anywhere—or true straight bevel gear cutting machines either, for that matter. The world lead which Maudslay and Whitworth gave us was lost about fifty years ago.

Machine-tool design is basic engineering nowadays, vital to our national existence, providing not only all the necessary tools but also one of the finest training grounds for other engineering work. Why have we fallen behind? Is it because the subject has attracted so little, if any, attention from our leading scientific or educational bodies such as the Royal Society, the D.S.I.R., or the university schools of engineering? Or is it because our own machine-tool manufacturers act so largely as agents for their own foreign competitors?

Yours faithfully,

HUGH CLAUSEN.

November 25, 1955.

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PROFESSIONAL ENGINEER AND HIS EMPLOYER

SIR, The article in your issue of November 18, entitled "The Professional Engineer and His Employer" raises several important matters.

Firstly, your contributor doubts the reality of a distinctive standard of professional behaviour, and suggests that this is no more than good citizenship. Professional conduct in its best sense nevertheless represents a standard of behaviour through which individual members express the dignity of their profession; a standard higher, in fact, than that generally expected of those who are not members of a profession. In terms of citizenship it sets a standard for the *best* citizenship. In the case of salaried employees, moreover, membership of a profession implies acceptance of a duty to that profession in addition to the normal duty owed to an employer.

Your correspondent rightly summarises the objects of the Guild as being "to unite the profession and raise its status." But improved status, like happiness, cannot be achieved by direct action; both are by-products of other factors. Improved salaries thus do not create higher status, but reflect it. Engineers do not ask "for recognition that they are not as other men," but for recognition that they have as important a part to play in the life of the community as have the members of any other profession. This recognition is far from being given universally to-day. It is one of the tasks of the Guild to bring about a better understanding of the work of the engineering profession.

Your contributor also refers to the "trade-union type bodies" which have grown to positions of power, and which represent large sections of professional staff—and frequently large numbers of technical and clerical staff also—in particular fields of employment. Through the negotiating machinery on which they are represented the salaries and conditions of service of those professional staffs are determined. Many professional men nevertheless feel that their particular interests are not always adequately represented, and there is the added risk that under such conditions their sense of unity with other members of their profession, wherever employed, may be weakened. This problem has been attacked in America through the medium of the so-called "professional union," a line of approach which has raised its own peculiar difficulties, not least in creating a division between employer and employee members of the same profession. In this country it has hitherto hardly been attacked at all.

The Engineers' Guild has lately been giving very close attention to the problem of ensuring the most effective representation of professional engineers in all fields of employment, but particularly in those where joint negotiating machinery has already been set up. The existing pattern of negotiating machinery is unlikely to undergo substantial alteration in the foreseeable future, and it has the merit of practical convenience from the point of view of the employing authority. For these reasons the Guild is consulting with other professional bodies to discuss whether a satisfactory solution can be found in joint action to influence negotiating bodies on matters of professional concern. If a start can be made in this way it may be extended to private industry as opportunity offers, although it is recognised that its introduction is not necessarily desirable in all cases.

Yours faithfully,

J. H. W. TURNER,
Hon. Secretary.

Engineers' Guild Limited,
London, S.W.1. November 28, 1955.

PERSONAL

SIR GODFREY INCE, G.C.B., K.B.E., B.Sc., LL.D., permanent secretary of the Ministry of Labour and National Service, who is to retire from the Civil Service in January, 1956, has been appointed chairman of Cable and Wireless Ltd., Mercury House, Theobald's-road, London, W.C.1, and their associated companies, in succession to MAJOR-GENERAL SIR LESLIE NICHOLLS, C.B., C.B.E., M.I.E.E., who decided, some months ago, to relinquish office on January 31, 1956. Sir Godfrey will take up his new post on February 1, 1956.

SIR WALTER DRUMMOND, M.I.C.E., M.I.Mech.E., formerly deputy chairman of the National Coal Board, and PROFESSOR N. F. MOTT, D.Sc., F.R.S., Cavendish Professor in the University of Cambridge, have been appointed, by the Department of Scientific and Industrial Research, to be D.S.I.R. visitors to the British Electrical and Allied Industries Research Association, in succession to DR. P. DUNSHEATH, C.B.E., M.A., M.I.E.E., and PROFESSOR J. T. RANDALL, D.Sc., F.Inst.P., F.R.S., whose period of service has been completed.

LORD RENNELL OF RODD, K.B.E., C.B., M.A., D.L., has been appointed deputy chairman of the British Overseas Airways Corporation in succession to MR. WHITNEY STRAIGHT, C.B.E., M.C., D.F.C., who has joined Rolls-Royce Ltd. SIR MILES THOMAS, D.F.C., M.I.Mech.E., the chairman of B.O.A.C., is both chairman of the Board and chief executive officer and is assisted by the deputy chairman and by the deputy chief executive officer, MR. BASIL SMALLPEICE.

MR. G. W. ALEXANDER, B.Sc., M.I.E.E., A.M.I.Min.E., has been appointed chief engineer of Powell Duffryn Ltd. This necessitates his relinquishment of executive responsibilities in Powell Duffryn Technical Services Ltd., and steps are being taken to appoint his successor. Mr. Alexander will continue to be a member of the board of that company.

LORD TWEEDSMUIR, O.B.E., LL.D., has been re-elected President of the Federation of Commonwealth and British Empire Chambers of Commerce, 69 Cannon-street, London, E.C.4.

MR. JOHN JACKSON has been appointed assistant manager to Clay Cross (Iron and Foundries) Ltd., and associate companies. He is the son of COLONEL H. H. JACKSON, and his appointment marks the fifth generation of the family to take up executive status with the company.

MR. F. C. PYMAN is to retire on December 31 from his position of managing director of William Gray and Co. Ltd., West Hartlepool.

MR. T. GOLDING, O.B.E., A.M.I.E.E., and Mr. A. H. HOOKE have been elected to the board of W. H. Allen Sons & Co. Ltd., Queens Engineering Works, Bedford.

MR. W. T. SPITTLE, superintendent at West Ham power station, London Division, Central Electricity Authority, is retiring in December. MR. A. H. CHANDLER, at present his deputy at West Ham, will be the new superintendent.

MR. D. J. CRABBE, who has been works director of the Brazil factory of the Dunlop Rubber Co. Ltd. since last year, has now returned to the firm's Speke factory as chief engineer.

MR. JAMES ROYCE has joined Hedin Ltd., Commerce Estate, Raven-road, South Woodford, London, E.18, to extend their manufacturing range to include furnaces of all types, with particular reference to high-temperature work.

MR. B. S. WORRALL, A.M.I.E.E., has been appointed sales manager, electrical equipment, to Henry Meadows Ltd., Fallings Park, Wolverhampton.

MR. O. L. WELBORN has been appointed general representative for the South-West Area of Sunvic Controls Ltd., 10 Essex-street, Strand, London, W.C.2. MR. W. J. DONNELLY has been appointed technical representative for the Midlands area for the firm's scientific and industrial division.

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COMMERCIAL

THE G.E.C.-SIMON CARVES INDUSTRIAL ATOMIC ENERGY GROUP have come to an arrangement with the MOTHERWELL BRIDGE AND ENGINEERING CO. LTD., under which the latter company will be associated with them in the construction of nuclear power stations.

THE BIRTLEY CO. LTD., Birtley, Co. Durham, have announced that, under licence from the CATERPILLAR TRACTOR CO., Illinois, U.S.A., they are to build the Caterpillar Lowbowl scraper, No. 463, of 25 cub. yd. capacity. The company are also to start building models Nos. 456 and 470, of 18 cub. yd. and 25 cub. yd. capacities, respectively.

As and from November 21 the name of SHEET METAL SPECIALTIES LTD., 1, Brandon Road, London, N.7, has been changed to ZEPHAIR LTD.

The address of the Peterborough office of MITCHELL ENGINEERING LTD., has been changed to: The Bridge, Peterborough, Northamptonshire. The telephone numbers and telegraphic address are unchanged.

So as to cope with new demands on specialised instrumentation, ROCKE INTERNATIONAL LTD., 59–61 Union-street, London, S.E.1, have announced that the operations of B. & K. LABORATORIES LTD., of the same address, are now available to clients. MR. C. J. MITCHELL, A.M.I.E.E., formerly of Racal Ltd., has been appointed chief engineer, while MR. V. R. MOORE, who has spent many years with Advance Components Ltd., has also joined the staff. MR. G. W. BOWYER is now in charge of the traffic department.

ELECTRIC AND MUSICAL INDUSTRIES LTD., and COLLARO LTD., have both concluded licence agreements with the A. R. F. DEVELOPMENT CORPORATION, a subsidiary concern of the ARMOUR RESEARCH FOUNDATION OF THE ILLINOIS INSTITUTE OF TECHNOLOGY, Chicago, U.S.A., which will enable them to use the patents held by Armour in the field of magnetic recording.

THE CANADIAN CONSTRUCTION ASSOCIATION informs us that their headquarters are now in Construction House, 151 O'Connor-street, Ottawa, 4, Canada.

As from December 5, PLASTER PRODUCTS (GREENHITHE) LTD., Greenhithe, Kent, are moving their London office from Windsor House, Victoria-street, S.W.1, to Bath House, 82 Piccadilly, W.1. (Telephone: GROsvenor 1171.)

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CONTRACTS

Diesel Locomotives. The British Transport Commission have placed contracts of a total value of nearly £10 million, with manufacturers in the United Kingdom, for 141 main-line Diesel locomotives. These comprise 130 Diesel-electric and 11 Diesel-hydraulic locomotives, and 30 power units which will be used for locomotives to be built in British Railway workshops. The contracts are part of the £1,200 million plan in progress for the modernisation and re-equipment of British Railways. They comprise three main designs: Type A, of 800 to 1,000 h.p., for freight; Type B, of 1,000 to 1,250 h.p., for mixed traffic; and Type C, of 2,000 h.p., or over, for heavy duties.

The contracts for complete locomotives have been placed as follows:

THE BIRMINGHAM RAILWAY CARRIAGE AND WAGON CO. LTD., Smethwick: 20 locomotives of type B.

THE BRITISH THOMSON-HOUSTON CO., LTD., Rugby: 10 locomotives of type A.

BRUSH BAGNALL TRACTION LTD., Loughborough: 20 locomotives of type B.

THE ENGLISH ELECTRIC CO. LTD., Bradford: 10 locomotives of type C, 10 of type B and 20 of type A.

THE METROPOLITAN-VICKERS ELECTRICAL CO. LTD., Manchester: 20 locomotives of type B.

THE NORTH BRITISH LOCOMOTIVE CO. LTD., Glasgow: 10 locomotives for type B and 10 of type A. Also 11 Diesel-hydraulic locomotives, 6 of type B and 5 of type C.

Contracts for power equipment sets for locomotives to be built in British Railways' workshops have been placed with: SULZER BROS. (LONDON) LTD., for 10 sets for locomotives of type C and with the BRITISH THOMSON-HOUSTON CO. LTD., Rugby, for 20 sets for locomotives of type B.

Further details regarding the locomotives and power equipment sets are given in Table I.

The main contracts will also involve substantial orders for engines, electrical equipment and mechanical parts. Details of this further allocation are given in Table II.

The abbreviations used in the tables include: Birm. C. & W., for Birmingham Railway Carriage and Wagon Co. Ltd., Smethwick; Brit. Rlys., for British Railways; B.T.H. for the British Thomson-Houston Co. Ltd.; Brush B., for Brush Bagnall Traction Ltd., Loughborough; Clayton, for the Clayton Equipment Co. Ltd., Tutbury; Crompt. Park., for Crompton Parkinson Ltd., Chelmsford; Crossley, for Crossley Brothers, Ltd., Manchester; Davey Paxman, for Davey, Paxman & Co. Ltd., Colchester; Eng. Elec. for the English Electric Co. Ltd., Bradford; G.E.C., for the General Electric Co. Ltd., Birmingham; Metro-Vick. for the Metropolitan-Vickers Electrical Co. Ltd., Manchester; Mirrlees, for Mirrlees, Bickerton & Day, Ltd., Stockport; N. Brit., for the North British Locomotive Co. Ltd., Glasgow; Sulzer, for Sulzer Bros. (London), Ltd.; and Voith, for Voith Hydraulic Equipments.

TABLE I.—*Main Contracts for Locomotives*

Main contractors	Wheel arrangement	H.p.	Operating Region			Total locos.
			L.M.	Westn.	Eastn.	
Type C						
Eng. Elec. ..	1CC1	2,000	—	—	10	10
N. Brit. ..	A1AA1A	2,000	—	5	—	5
Totals ..	—	—	—	5	10	15
Type B						
Eng. Elec. ..	BB	1,100	—	—	10	10
Birm. C. & W.	BB	1,160	—	—	20	20
Brush B. ..	CC	1,250	—	—	20	20
N. Brit. ..	BB	1,000	—	6	10	16
Metro-Vick. ..	CB	1,200	20	—	—	20
Totals ..	—	—	20	6	60	86
Type A						
Eng. Elec. ..	BB	1,000	20	—	—	20
B.T.H. ..	BB	800	10	—	—	10
N. Brit. ..	BB	800	—	—	10	10
Totals ..	—	—	30	—	10	40
Total locos. by contractors ..	—	—	50	11	80	141
Power Equipt. Sets: Type C						
Sulzer ..	1CC1	2,300	10	—	—	10
Power Equipt. Sets: Type B						
B.T.H. ..	BB	1,160	20	—	—	20
Total power equipt. sets for locos. to be built in rly. workshops ..	—	—	30	—	—	30
Grand totals..	—	—	80	11	80	171

TABLE II.—*Contractors for Equipment*

No.	Main contractor	Engine	Transmission equipment	Mech-parts
Type C Power Equipts.				
10	Sulzer ..	Sulzer ..	Crompt.-Park.	Brit. Rlys.
Complete Locos.				
10	Eng. Elec. ..	Eng. Elec.	Eng. Elec. ..	Eng. Elec.
5	N. Brit. ..	M.A.N.	Voith ..	N. Brit.
Type B Power Equipts.				
20	B.T.H. ..	Sulzer ..	B.T.H. ..	Brit. Rlys.
Complete Locos.				
10	Eng. Elec. ..	E.E.C. Deltic	Eng. Elec. ..	Eng. Elec.
20	Birm. C. & W.	Sulzer	Cromp.-Park.	Birm.C. & W.
20	Brush B. ..	Mirrlees..	Brush ..	Bagnall
20	Metro-Vick.	Crossley..	Metro-Vick.	Metro-Vick.
10	N. Brit.	M.A.N.	G.E.C.	N. Brit.
6	N. Brit. ..	M.A.N. ..	Voith ..	N. Brit.
Type A Complete Locos.				
20	Eng. Elec. ..	Eng. Elec.	Eng. Elec. ..	Eng. Elec.
10	B.T.H. ..	Davey Paxman	B.T.H. ..	Clayton
10	N. Brit. ..	Davey Paxman	G.E.C.	N. Brit.

Main Building, Television Centre. The British Broadcasting Corporation, Broadcasting House, London, W.1, have placed a contract with GEORGE WIMPEY & CO., LTD., for the excavation and foundations of the main building to be erected at the Television Centre, Wood-lane, London, W.12. The area to be enclosed by the buildings will be 3½ acres.

Omnibuses. An Israeli delegation headed by the deputy controller of road transport in the Ministry of Communications of the State of Israel has signed a contract with LEYLAND MOTORS LTD., Leyland, Lancashire, for 250 omnibus chassis estimated to cost £1,000,000. The vehicles are all Leyland Royal Tiger Worldmaster models with 150 h.p. underfloor Diesel engines. The vehicles are expected to be allocated to the three largest omnibus co-operative undertakings in the country in the proportion of 150 to the Egged Co-operative which operates a passenger and parcels service covering the whole country; 75 to the Dan Co-operative which serves Tel-Aviv, and 25 to the Hamekasher Co-operative of Jerusalem.

Book Reviews

ELECTRIC TRACTION

Electric Traction Engineering: An Introduction. By E. A. BINNEY. Cleaver-Hume Electrical Series No. 10. *Cleaver-Hume Press, Limited, 31 Wright's-lane, Kensington, London, W.8.* (15*s.*)

There are few books in this country dealing with the equipment of electrically-propelled rail and road vehicles, and a book on electric traction engineering by an author well known in the traction industry is therefore a most welcome addition. It is particularly so at the present time, as railway electrification is not only passing through a period of technical change, but is facing a possibility of considerable expansion.

From the title one would expect a reasonable equality in the treatment of the various sections. This, however, is not the case. The design of powered vehicles is almost universally divided into three sections "general"—referred to as "project"—"machine" and "control." The author has so divided the book separately to cover these sections, but the chapters dealing with project and control are limited, while those covering machines are of a very high standard. To have treated all sections on a basis of equality in the space available would almost certainly have reduced the value of the book.

The author clearly indicates that the book is for student and young engineers, consequently the introduction to chapter I covering systems and history is most desirable, particularly when one remembers that electric traction has now passed its half century.

It is, however, somewhat surprising that no mention of coal economy is made in dealing with reasons for electrification. A little more information regarding Diesel-electric equipments as competitors would have been welcome as many consider that they have limited application, and that the introduction of 50 cycle equipment will be a competitor for certain Diesel-electric services.

Chapter II is obviously only of interest to the student or very young engineer. Since the "projects" engineering is the foundation for the other two sections mentioned, it seems a little misleading to place it fourth and cover it so briefly. That control engineering calls not so much for theoretical knowledge as practical knowledge, will surprise many. The control engineer is usually responsible for control apparatus design and requires a very considerable theoretical knowledge of mechanics, dynamics, electro-magnetics, are behaviour, etc. As a machine designer he must also know or develop many ratios, factors and maximum and minimum data, so that contactors, relays, coils and current carrying mechanisms may be designed satisfactorily to meet requirements at safe operating temperatures, and correct characteristics. One wonders whether in a book of limited size, chapter II could possibly have been replaced by a section on control apparatus design or general notes on locomotive design.

The four chapters on machine design are unusually good, being a logical and detailed development of machine design from the service requirements to be met to the complete design. They contain a wealth of technical design data and no student or young designer should fail to study them. They also form a most useful reference on machine principles for traction designers in other branches of the work and more than justify the publication. Some engineers may feel that an introduction to insulation problems might have been included, but the difficulty of doing this is readily appreciated. The whole question of adhesion is somewhat over simplified, and, in view of recent experience of the French Railways, an insight into nominal and effective adhesion due to weight transfer, and division of load between motors would have been an advantage.

The sound introduction to mechanical drives and motor mounting in chapter VII is an essential, but here again one would have welcomed some guidance on weight transfer problems and the way motor mounting may improve effective adhesion and influence the riding properties of the locomotives. The question that fully spring-borne motors might reduce bogie and track maintenance is referred to, although the author does not appear to feel they are justified at present.

The handling of traction control contains little more than descriptions of typical circuits and does not deal with apparatus design which forms a large portion of the control engineer's work. Many will congratulate the author for his introduction of the possibilities of the rotary amplifiers, as they feel that such may easily revolutionise control methods.

Mr. Binney's book is a most welcome addition to our limited literature of traction. To the student and young engineer it will be found invaluable.

Electric Railway Engineering. By T. FERGUSON. *Macdonald and Evans, Limited, 8 John-street, Bedford-row, London, W.C.1.* (57*s.* 6*d.*)

Electric Railway Engineering is a welcome addition to the limited literature published on the subject in Britain. Written by a well-known engineer, with a life-time experience, one would expect a good book, and one is not disappointed. The title is very general and some indication of the field covered seems desirable. The electrification of a railway embraces many subjects from traffic considerations, track alterations, station location and modified signalling to the detail design of all the electrical equipment associated with the vehicles, the substations, overhead line and transmission, together with the mechanical design of the vehicles.

Mr. Ferguson's book does not deal in any way with detail equipment design, but covers the many complex and technical subjects that form a bridge between the railway's general traffic requirements and the detail design of components for manufacture. Such is usually referred to as general or project engineering, and is considered by many as of major importance. Although the book may be regarded as suitable for the student it will appeal most strongly to the young project engineer, and the new-works engineers of the railways. Senior engineers in other branches of electric traction will welcome it as a book to be read and used as a reference. Some may feel that chapters 5, 6, 7, 8 and 9 might have been the opening chapters as they deal with fundamental principles of motion. They are well handled and contain much useful data. Since the reduction of weight transfer is becoming more important every day, due to increases of speed and loads hauled, chapter 8 might have been elaborated a little more. No very clear explanation of the advantages or otherwise of longitudinal steady bearers is given, nor the advantages of very low bogie thrust points. As is well known, steady bearers are a disadvantage in some cases. The fundamentals are, however, well treated.

The first four chapters deal with the electric motor and its requirements to meet service conditions. They not only fully describe the many subjects involved but contain useful data. If any criticism can be made it is that the form of the speed/tractive effort characteristic might have further explanation regarding division of load between motors, reduction of effective adhesion due to variations of tractive effort per axle and the benefits of certain forms of characteristic from the driving point of view and in the simplification of control. The importance of braking, both friction and electrical, together with the many auxiliary services, is fully emphasised.

The Diesel-electric and gas-turbine electric are not only very fully dealt with from the general engineering point of view, but detailed financial comparisons are made between them and straight electric traction, and similar comparisons are made between single-phase and different D.C. systems. It is, however, somewhat surprising that no reference is made to 50 cycle 25,000 volt electrification. This is receiving considerable attention to-day and is, perhaps, in a more advanced stage of development than the gas-turbine electric.

No technical book can completely cover the whole subject and its value to some degree depends on including certain limited information to form a transition to an associated subject. Chapter 13 is an excellent transition to the overhead line, substation and power supply, but some detailed information about rectifiers on regenerative systems, and the complex problems of protection against short circuits on the vehicle would have been an advantage.

The mechanical design of the locomotives has always presented difficulties. With the increase of speeds and train loads it is becoming a major problem in design. Not only must designs embody higher effective adhesion, but they must be suitable for operation at high speeds safely and without damage to the track. Chapter 19 is a good introduction to the subject, but can hardly be considered more. Many traction engineers will not agree with some views expressed by the author. For example, the benefits of fore and aft bearers do not apply in all cases and motor mounting referred to in 8-2-1, while of great benefit for high effective adhesion, may present difficulties in bogie design. Even for freight services the mounting of the drawgear on the bogie, together with articulation, is not always best. This chapter is too limited and does not embody sufficient introduction to the more modern views and recent practice.

The control side is somewhat neglected and only the simplest introduction to the subject is given. It does, however, deal with the question of starting notches and field control quite adequately and refers to the difficulties of the highly saturated motor.

No single book, even limited to the general or project side of railway electrification, can possibly cover all sections with desirable detail. One may, however, safely say that the author has gone far towards the single-book ideal and *Electric Railway Engineering* will almost certainly have a premier position in the traction world for a long time.

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INTERNATIONAL I.C. ENGINE CONGRESS

Written Contributions Invited

Following on the previous international congresses at Paris, Milan and The Hague, the fourth biennial International Internal Combustion Engine Congress will be held in mid-June, 1957, at Zürich. The theme of the forthcoming congress will embrace the current research results and future prospects of marine, traction and stationary supercharged Diesel engines and combustion turbines.

Interest in these international congresses lies essentially in their taking the form of discussions followed by technical visits, and the programme of meetings and visits to factories for the conference at Zürich will extend over one week. The total number of papers that can be admitted for discussion is limited to 24 and, in view of the importance of the theme, the British National Committee hope that a number of papers will be presented by authors in the United Kingdom. Intending contributors should send the titles of their papers, with short synopses and particulars of the illustrations required, to Mr. C. C. M. Logan, secretary, British National Committee, 6 Grafton-street, London, W.1, not later than February 1, 1956.

It may be recalled that it was in mid-September, 1954, at a meeting of representatives of the internal-combustion engine and related industries, that it was decided, for the first time, that the United Kingdom would be officially represented at future international congresses.

BOOKS RECEIVED

Some of the books noticed here are selected for extended review in ENGINEERING.

Fundamentals of Press Tool Design. By W. F. WALKER. *Crosby Lockwood and Son, Limited, 26 Old Brompton-road, London, S.W.7.* (12*s.* 6*d.*)

The author discusses the design of blanking, piercing, follow-on tools, cropping, notching, combination, perforating, clipping, and shaving tools; stripping, stops and pilot tools; pressure cushions; bending and forming; planishing; plunging and curling tools; raising, cupping and drawing; compound tools; the calculation of blank sizes; and tool materials.

Noise Measurement Techniques. N.P.L. Notes on Applied Science No. 10. Published for the Department of Scientific and Industrial Research by *H.M. Stationery Office, Kingsway, London, W.C.2.* (2*s.*)

The booklet is intended as a guide to the selection of methods, technique and equipment for the measurement of noise. It covers the characteristics of noise, wave-form recording and the principles of broad-band and narrow-band analysis, equipment and its operation, the calibration of microphones and complete measurements and the checking of auxiliary equipment.

Questions and Answers on Refrigeration. By M. E. ANDERSON. Third edition. *George Newnes, Limited, Tower House, Southampton-street, London, W.C.2.* (6*s.*)

The book covers physical principles, the vapour compression system, refrigerants, compressors, evaporator design, condensers, regulation, piping and pressure drop, cold storage and insulation, freezing of foods and ice making, dairy refrigeration, air conditioning, low temperatures, automatic controls, operation of plants, testing and rating, and the Electrolux refrigerator and Fridge-Heater heat pump.

The Science of Petroleum. Vol. V, Part III: Refinery Products. Edited by B. T. BROOKS and A. E. DUNSTAN. *Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.4.* (126*s.*)

The first four volumes of this series were published in 1937, but it was not till 1950 that the first supplementary section, vol. V, part I, appeared. Part II was published in 1953 and now part III completes the supplemental record in the field of petroleum chemistry and refining. The new volume contains 23 papers by different authors covering such diverse subjects as testing aviation gasolines, boundary lubrication and mass spectroscopy.

Telecommunications Principles and Practice. By W. T. PERKINS. *George Newnes, Limited, Tower House, Southampton-street, London, W.C.2.* (21*s.*)

This text-book is designed for the student in telecommunications and is based on the syllabuses laid down by the City and Guilds of London Institute. It begins with an outline of the fundamentals of electricity and magnetism, before going on to consider the particular applications in telecommunications. This is almost entirely confined to line telephony and telegraphy, with only the briefest reference to radio operation.

High Vacuum Technique: Theory, Practice, Industrial Applications and Properties of Materials. By J. YARWOOD. Third edition revised. *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (25*s.*)

The third edition includes much new post-war material concerning recent developments in the knowledge of high vacua. The volume begins with methods of obtaining high vacua, and then considers how to measure what has been obtained. The measurement of pumping speed is followed by descriptions of many industrial applications. The last section gives a comprehensive list of properties of materials that are important in high vacuum work.

The Physics of the Ionosphere. Report of the Physical Society Conference held at the Cavendish Laboratory, Cambridge, September, 1954. *The Physical Society, 1 Lowther-gardens, Prince Consort-road, London, S.W.7.* (40*s.*)

The number and complexity of unsolved problems in the physics of the high atmosphere is almost staggering, and that part of the high atmosphere known as the ionosphere has recently been receiving considerable attention. The ionosphere is the ionised region high up in the stratosphere from which wireless waves are reflected. Rocket measurements and radio techniques are perhaps the principal means, under an experimenter's control, for investigating the character and properties of this region, and these methods have been used extensively to obtain the results recorded in this report. The report contains some 50 papers on various aspects of the subject under the following major headings: "The Lowest Ionosphere"; "Irregularities and Movements in the Ionosphere"; "The Ionospheric F2 Layer"; and "The Mathematics of Wave Propagation through the Ionosphere". The contributors to the conference, which was international in scope, included Sir Edward Appleton. The report is well illustrated.

Mathematics for Higher National Certificate: A Text Book for the Use of First Year (A1) Students. Vol. I. By S. W. BELL and H. MATLEY. *Cambridge University Press, Bentley House, 200 Euston-road, London, N.W.1.* (15*s.*)

The authors of this book recognise that most students reading mathematics as part of a course for the Higher National Certificate in Engineering will be part-time students at technical colleges, and will therefore have only a very limited time to devote to that subject. For this reason, the book has been confined to the main essentials of such a course with emphasis on conciseness, and as many worked examples and exercises as possible have been included. Particular topics treated in volume one are differentiation and integration, hyperbolic and inverse functions, evolutes and involutes, infinite series, the catenary, complex numbers, and harmonic analysis; there are also separate sections on applications to mechanical and electrical engineering. Diagrams are used to illustrate the text and an index is provided.

Winding in Staple-Pits. National Coal Board (Production) Codes and Rules. *National Coal Board, Production Department, Hobart House, Grosvenor-place, London, S.W.1.* (2*s.*)

This code of practice sets out the National Coal Board's rules and statutory provisions governing winding practice and equipment in staple pits. The rules are additional to and in amplification of, and not in substitution for, the Coal Mines Act, 1911, the Mines and Quarries Act, 1954 (which is not yet in force), or the statutory regulations.

Capstan and Turret Lathe Practice. By C. MONDAY. *The Machinery Publishing Company, Limited, National House, West-street, Brighton, 1.* (17*s.* 6*d.*)

The practical aspect of the subject is the main concern of this book which is intended for those who are engaged in the drawing office or workshop. Lathe types and construction are described, and the work for which they are suitable; tools and work holders are also considered in some detail. Setting up and operating are dealt with, and screw cutting has particular consideration in view of the large amount done on these types of lathe.

Boiler House and Power Station Chemistry. By WILFRID FRANCIS. Third edition. *Edward Arnold (Publishers), Limited, 41 Maddox-street, London, W.1.* (50*s.*)

This book was originally written to provide chemists, students of fuel technology and operators of boiler plant with an introduction to the chemical considerations involved in the combustion of coal and in the generation of electricity. In this edition, owing to the shortage of coal, a description has been included of the properties and preparation of alternative fuels with methods for the rapid calculation of combustion engineering data relating to them. More space has also been devoted to boiler availability, to methods of cleaning boilers and to the analysis of the fly ash from boiler flues and passes. Improved methods of analysing coal and coke ash are also described.

Elements of Electronics. By HENRY V. HICKEY and WILLIAM M. VILLINES. *McGraw-Hill Book Company, Incorporated, 330 West 42nd-street, New York 36, N.Y., U.S.A.* (5 dols.); and *McGraw-Hill Publishing Company, Limited, 95 Farringdon-street, London, E.C.4.* (37*s.* 6*d.*)

Both authors are attached to the U.S. Navy (H. V. Hickey being the Chief Radio Electrician) and this text-book is based on their experiences. The wide field is covered in considerable detail, with brief sections on fundamental principles at each stage. Review questions follow each of the 50 chapters.

Wave Diagrams for Nonsteady Flow in Ducts. By GEORGE RUDINGER. *D. Van Nostrand Company, Incorporated, 250 Fourth-avenue, New York 3, N.Y., U.S.A.* (6 dols.); and *Macmillan and Company, Limited, St. Martin's-street, London, W.C.2.* (45*s.*)

The author's aim is to provide a consistent set of computing procedures for the construction of wave diagrams for solving problems of non-steady gas flow. After discussing the assumptions, selection of flow variables, basic equations and derivation of the characteristics relations, step-by-step procedure for constructing wave diagrams is given and types of pressure waves are discussed. This is followed by chapters on general flow problems, boundaries and discontinuities, the interaction of discontinuities, techniques of wave diagram construction, and examples. A bibliography of 96 references, charts and tables for expediting computation, and an appendix on steady-flow relations are included.

Differential Equations. By LESTER R. FORD. Second edition. *McGraw-Hill Book Company, Incorporated, 330 West 42nd-street, New York 36, N.Y., U.S.A.* (5 dols.); and *McGraw-Hill Publishing Company, Limited, 95 Farringdon-street, London, E.C.4.* (37*s.* 6*d.*)

This work on ordinary and partial differential equations is designed as an intermediate text between elementary books and advanced treatments demanding a high standard of mathematical knowledge. The introductory chapters stress the geometric approach and elementary methods. These are followed by statements and proofs of existence theorems reduced to their simplest forms. Laplace transforms are introduced, and articles are included on elastic vibrations, planetary orbits, wave motion, and the flow of heat. Additional methods of numerical solution are given, including that used in potential theory and the flow of heat. Problems and answers are included.

Basic Sheet-Metal Practice. By J. W. GIACHINO. *International Textbook Company, Scranton, Pennsylvania, U.S.A.* (4 dols.); and *Macmillan and Company, Limited, St. Martin's-street, London, W.C.2.* (28*s.*)

The author is head of the Vocational-Industrial and Technical Education Department of the Western Michigan College of Education, and has laid out this book as a practical guide to apprentices. Every aspect of sheet metal work—laying out, bending, jointing and finishing—is described both when carried out by hand and by machine. At the end of the volume is a series of practice exercises and a number of useful articles which employ various techniques for their production. Throughout the book, each operation is clearly illustrated by diagrams.

Basic Lubrication Practice. By ALLEN F. BREWER. *Reinhold Publishing Corporation, 430 Park-avenue, New York 22, N.Y., U.S.A.* (6.75 dols.); and *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (54*s.*)

The author, who is a former editor of the magazine *Lubrication*, says in his preface that "Designing for lubrication is as important as designing for production." In this volume he sets out to supply the operator and the student with detailed information on the present knowledge and practice of machine lubrication. Sections on bearings—plain, roller and ball—gears, motors, compressors and steam and internal combustion engines are included, as well as notes on the testing of lubricants.

Servicing Guide to British Motor Vehicles. Vol. 3: Cars, Commercial Vehicles, Tractors and Components. By A. J. K. MOSS. Published for "Motor Trader" and "British Automobiles Overseas" by *Trader Publishing Company, Limited, Dorset House, Stamford-street, London, S.E.1.* (50*s.*)

Guides are given to the servicing of 18 cars, six commercial vehicles and one tractor, all 1953-54-55 models. Four components (including the Perkins P6 engine) are described. All these sheets have previously appeared in *Motor Trader*.

The Cooling of Electric Machines and Cables. By THEODORE DE KONING. *Zuid Nederlandsche Drukkery, s'Hertogenbosch, Holland.* (18 Dutch guilders (35*s.*).)

The author claims that this is the first book to be published on the cooling of electrical equipment and discusses methods whereby the present limitations imposed by heating on the design of such equipment can be overcome. With this as a general thesis applications to generators, motors and cables are dealt with. It is written in such a way that an engineering secretary or first-year student can understand it. Our copy bears an inscription to the effect that it is not permitted on the premises of electrical manufacturers.

The Foreseeable Future. By SIR GEORGE THOMSON, F.R.S. *Cambridge University Press, Bentley House, 200 Euston-road, London, N.W.1.* (10*s.* 6*d.*) (Reviewed on page 720, in the issue of November 25.)

Dynamics of Machinery. By A. R. HOLOWENKO. *John Wiley and Sons, Incorporated, 440 Fourth-avenue, New York 16, N.Y., U.S.A.* (7.50 dols.); and *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (60*s.*) (Reviewed on page 720, in the issue of November 25.)

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

The Beama Catalogue 1955-56. BRITISH ELECTRICAL AND ALLIED MANUFACTURERS' ASSOCIATION, 36 Kingsway, London, W.C.2. Products manufactured by member firms classified in three sections—electrical power plant; electrical equipment in industry, transport and communications; and domestic and commercial electrical appliances, lighting, accessories and installation material—printed in different colours. Classified buyers guide listing the range of equipment manufactured by Beama firms under 1,200 headings. Trade directory giving principal addresses in the United Kingdom of subsidiary and branch offices. Over 4,000 names and addresses, grouped territorially, of member firms overseas branches, representatives and agents. A five-language glossary of the technical terms used in the buyers guide. Product headings listed in English, French, German. Portuguese and Spanish to provide a key to the equivalent technical terms used in other countries. Profusely illustrated volume of 1,034 pages.

Knitted Wire and Plastics Mesh. KNITTED MESH MANUFACTURING CO., 36 Victoria-street, London, S.W.1. Knit Mesh, in aluminium, Monel, stainless steel, galvanised steel, brass, copper, phosphor bronze, Nylon, p.v.c., Courlene, Saran, polythene, perlon or grilon, for air filters, electronic shields, mist eliminators, vibrator cushions, etc. Illustrated leaflets in folder.

Metal Fixing Systems. METAL FIXING ASSOCIATION, 23 Queen Anne-street, London, W.1. Code of practice and manual for light-weight metal fixing systems for building linings and ceilings. Second edition. Covers components, anti-corrosion protection, lining or sheet materials, supporting and positioning sheet materials, concealed fixing systems, erection, scaffolding, specification.

Aluminium Building Sheets. NORTHERN ALUMINIUM CO. LTD., Banbury, Oxfordshire. Noral Snaprit sheet, incorporating simple snap joint along full length of overlapping corrugations. Surface free from nails, screws or holes, therefore weather tight. Illustrated descriptive brochure with instructions for erection.

Electric Jackets for Pipes and Columns. ISOPAD LTD., 30-32 Rosemont-road, London, N.W.3. Isojackets, combined electric heating and lagging units for columns, pipes and cylindrical vessels. Standard units up to 400 deg. C., quartz cloth jackets up to 800 deg. C. Illustrated descriptive leaflet and specification.

Flush Electric Switches. J. A. CRABTREE & CO. LTD., Lincoln Works, Walsall, Staffordshire. Flush electric switches for alternating-current circuits, operating on short-break principle and including new triple-switch and twin-twin units. Illustrated leaflet.

Off-Circuit Tapping Switches. FOSTER TRANSFORMERS LTD., South Wimbledon, London, S.W.19. Details of the three main types of off-circuit tapping switches made for use on the company's oil-immersed power and distribution transformers. Illustrated leaflet.

Air-Cooled Transformers. FOSTER TRANSFORMERS LTD., South Wimbledon, London, S.W.19. Single-phase double-wound air-cooled transformers with outputs from 20 to 500 volt-amperes and from 600 to 4,500 volt-amperes. Technical details and physical dimensions. Illustrated leaflets.

Coarse and Medium-Size Screen. INTERNATIONAL COMBUSTION LTD., 19 Woburn-place, London, W.1. Ty-Rock full-floating screen for coarse and medium-sized screening of crushed rock, gravel, ores, coal, and other materials. Illustrated descriptive brochure with table of dimensions.

Oxygen and Temperature Recorder. GEORGE KENT LTD., Luton, Bedfordshire. Combined oxygen and temperature recorder for boiler-houses; ranges 0 to 15 per cent. oxygen and 0 to 1,000 deg. F. Illustrated leaflet with specification and dimensions.

Aluminium Busbars. ALUMINIUM UNION, LTD., The Adelphi, London, W.C.2. Advantages of aluminium busbars for electrical purposes with examples of the ways in which they have been utilised. Illustrated pamphlet.

Metalclad Plugs and Sockets. A. REYROLLE & CO. LTD., Hebburn, Co. Durham. "Easigo" metal-clad protected plugs and sockets for capacities of 5, 15 and 30 amperes. Technical descriptions, dimensions and prices. Illustrated leaflet.

Commercial Trailers. PARION PRODUCTS LTD., Witham, Essex. Caravans for mobile exhibitions, offices, reception, etc. Illustrated leaflet.

THE RUSSIAN IRON AND STEEL INDUSTRY

LARGE MODERN PLANTS GIVE HIGH QUALITY PRODUCTS

By W. F. Cartwright, M.I.MECH.E.

Representatives of the British steel industry have recently visited iron and steel plants in the Soviet Union and two lectures reporting their visit have been delivered before members of the Iron and Steel Institute. The first lecture, given by Sir Robert Shone, C.B.E., leader of the party, was reported in ENGINEERING *last week (page 716). The following article is an abridged version of a lecture delivered by another member of the party, Mr. W. F. Cartright, M.I.Mech.E., assistant managing director of the Steel Company of Wales Limited, on November 16, and deals with the coke ovens, blast furnaces, open-hearth steel plants and rolling mills visited.*

COKE OVENS

There were about 20 of us in the delegation, and I can truthfully say, after visiting many works all over the world, that I have never before had such freedom to make notes, to ask questions and to study what was going on in the various plants as we had on this trip.

As in any other country, presumably, there is quite a wide range between the best and the worst. I do not know, of course, what the range is between the worst and the best in Russia, because generally speaking we saw some of their newest and some of their best.

We visited two coke plants, one about 30 km. outside Moscow and the other at Stalino, and both are about four years old. The coal arrives in complete trains. This fuel is rather high in ash and rather high in sulphur, the average sulphur in the coke being about 1·3 per cent. At the Moscow coke works the ash is a little lower than at the Rustavi works, in Georgia, where the average ash in the coke runs between 16½ per cent. and 18½ per cent.—what we should call very high. Even so, at the Moscow coke works the whole of the coke intended for blast furnaces appeared to be physically of good quality, although the volatile matter in the mixture was 27 per cent.

The coal arrives in 60 ton double-bogie wagons and is tipped in 2,000 tons per hour tipplers, and then goes by belt to stock—there is a very comprehensive stocking plant, I expect to guard against the winter—or to blending bunkers. It is then distributed throughout the works.

At the Moscow plant there are four batteries each containing 37 ovens. The whole of the gas goes to Moscow and the heating is done by producer gas. The producer gas is made from anthracite and coke breeze. The producers are of a very efficient type, with electrostatic gas cleaning and balanced draught, blowers and exhausters running on a balanced pressure, and waste-heat boilers round the producers. About 100 yards away from the ovens there is a power station, with two 8 MW sets, running at 45 atmospheres. The steam is dropped to 7 atmospheres for use round the plant in various ways, such as in the gas producers and in the extensive space-heating installations which have to be provided for Russian conditions.

CLEANLINESS AND MAINTENANCE

What impressed me most at both these plants, however, was the extraordinary absence of smoke. Moreover, everything was spotlessly clean. The pins and joints of all the valves were kept polished, and so bright that they seemed to be made of stainless steel. The pumps and pump machinery were all kept very bright indeed.

This was only one of many indications that the Russians certainly know how to maintain their machinery. Throughout the plants, and not only at the coke ovens, there was a very noticeable absence of oil leaks, steam leaks or blast leaks. For instance, underground in the Krivoi Rog mine we never heard a hiss from a leaking joint in the whole of the air-main system, and almost invariably when we looked at the central lubrication and grease system we saw that the manifolds were polished, and very often the pipes as well. In the Moscow cokeworks all the machinery was kept brightly painted, but by our standards the office buildings were not well finished off at all. The Russians appeared to pay little attention to finishing off such things as stairs and window-frames and doors. It was a rather surprising contrast.

BLAST FURNACES

Of the two blast-furnace plants which we saw, that at Zaporozhe, in the Ukraine, was the more interesting. The other, at Rustavi, Georgia, is in an area where there had been no steelworks before, and the Russians have had to do a great deal of work in training their people there. In the case of Zaporozhe, however, the plant was started up about 1933 and was in full operation about three years later. When the Dnieper dam was blown up, it was not very far from the steelworks, but work was begun again in 1947 and at least one of the blast furnaces has been in operation since that year. There are five furnaces, all on high top pressure, blowing at about 27 lb. per square inch at the bottom and working under about 5 lb. per square inch at the top. A great deal of sinter is being used in the burden, but it is planned to use more and eventually to work with 100 per cent. sinter. The furnaces all have hearth diameters of 26 ft., but other dimensions vary. The smallest makes 1,000 tons of iron a day, and the largest 1,750 tons—quite impressive outputs.

EXTENSIVE INSTRUMENTATION

Like all Russian plants, they are very extensively instrumented. The high top-pressure instrumentation, for example, is most elaborate. Slag ladles tilted electrically are employed. The Rustavi furnaces are not working as well as those at Zaporozhe, nor have they the high top pressure, but it is obvious that managements in Russia, with whom we had some conversation, think that high top pressure has come to stay. Although Zaporozhe is making very big outputs, the coke consumption figures are not as low as might be expected from the very good raw material which is used, containing 56 to 58 per cent. iron. The coke figure is between 17 and 18 cwt. per ton of iron. The furnaces are blown very hard; at a rate of over 100,000 cub. ft. per minute.

At Rustavi the furnaces have 19 ft. diameter hearths. The furnaces are smaller than at Zaporozhe for some reason which we did not follow, although they are new; it may be because the whole plant is smaller. The rate of blowing at Rustavi is also high; the rate being 50,000 cub. ft. per minute; there, too, they have an ore which is fairly rich in iron. The Krivoi Rog ore is very fine indeed without any preparation, but it lends itself to the 100 per cent. preparation idea. The ore deposit at Krivoi Rog is enormous; it is 260 km. long and about 8 km. wide. The Russians deliberately, and in my opinion rightly, have developed a technique of mining it fairly evenly. The bottom of the deposit is hematite and high in iron, and in the outcrops, or near them, it is magnetite and low in iron, 35 per cent., but this magnetite is being concentrated to 58 to 60 per cent. iron.

At the big concentration plant, which we saw, it was interesting to find that a self-fluxing sinter was being or about to be made. Sea-shells from Balaclava were brought to mix with the iron concentrate to produce a completely self-fluxing sinter. It was a very impressive sight to see this gigantic concentration plant, with 14 ball mills already in position and plans for 50, and with some 7 sintering strands of 75 sq. metres each. The plant was just being started up. It is necessary to remember that in that area it can be very hot in summer and very cold in winter. The most elaborate arrangements have to be made to deal with the ventilation problem and must be able to supply air to the sinter plant without bringing cold draughts to the operators.

OPEN-HEARTH STEEL PLANT

The Zaporozhe, steelworks, is, I suppose one can say, an American-style plant, with 200 ton fixed furnaces, 10 of them in a row, with two mixers in a separate building joined by a metal track running down the backs of the furnaces, with slewing ground chargers. I can truthfully report that the plant is working well.

On our visit, all ten furnaces were in commission. The tap-to-tap time which was planned was 7 hours 45 minutes. We went up and down the shop looking at the times on the boards which were actually achieved, the reasons why they were down, and so on. The worst tap-to-tap time that day was 10½ hours, but the same furnace had not done too badly, because it had had one time of 5 hours 20 minutes. The reasons for these good times are fairly clear. The pig iron is of high quality, containing 0·18 per cent. phosphorus, 2·7 per cent. manganese, 0·7 per cent. silicon and 0·04 per cent. sulphur. Some 70 per cent. of molten metal is used and this is drawn exactly when required; there is an ample supply, because the pig-iron production is over two million tons and the steel production only about 1,800,000 tons. A standard scrap charge has been adopted and this consists of 12 bogies with four scrap boxes per bogie, or 48 altogether. The same quantity of scrap bundles is always provided. The scrap is from the motor-car works at Gorki but rolling-mill scrap is also available, while limestone and lime are provided at the charging point.

MIXED-GAS FIRING

The furnaces are not, as might be expected, oil-fired; they are mixed-gas fired, namely a mixture of blast-furnace and coke-oven gas. The air is enriched with up to 25 per cent. oxygen and the furnaces are provided with chrome-magnesite roofs, not with spring skew-backs and not suspended, but with a very pronounced rise. It appeared that no troubles of any description were being experienced throughout the shop. An "enormous quantity" of instruments was provided.

The cranes, by American standards, would be considered light. Throughout Russia I noticed a great liking for roller-bearings; we saw roller-bearings used everywhere, and there was a most extensive use of roller-bearings on the cranes, I did not see any crane down for repair, but I did see the long-travel mechanism disconnected on one side of one of the ground chargers, but I did not ascertain the reason.

BOTTOM POURING

On the pit side we were surprised to find that the technique of bottom pouring of the rimming steel had been adopted. At the moment the largest ingot on the large strip rolling mill is 12 tons, but the size is to be enlarged to 16 tons. Four 12 ton ingots are cast on one bogie, on one bottom plate, with one trumpet, and this is considered well worth while on account of the surface improvement. The insides of the moulds are tarred in the open air, to get over atmospheric troubles. I did not see how they managed when it rained, but there was no roof protection at all. Generally speaking, the shop at Zaporozhe was a credit to all concerned; we had a feeling of great urgency and alertness on the part of everybody there.

At Rustavi the steel shop is not in the same class. There are six 125 ton furnaces and a mixer. The furnaces are being enlarged to 150 tons. At the moment they are on oil firing, but it is intended to change over to mixed gas, following the excellent example of Zaporozhe.

Although I have said that Rustavi was not so good as Zaporozhe, I am bound to say that, no doubt partly owing to their excellent raw materials, good outputs are achieved; they appear, in fact, to average 2,500 tons per week and per furnace. The average at Zaporozhe is more like 4,200 tons per week per furnace.

ROLLING MILLS

When we come to rolling mills, I feel that there is not so much of interest to tell you, and the Russians are conscious of the fact that there is much to be done. At present, apparently, they have at Zaporozhe a 66 in. mill made by "United" about 1936. During the war it was taken out of the reach of the Germans and brought back again. It is a low-lift universal slabbing mill, and it was rolling 2,000 tons of ingots per shift, with a record shift of 2,500 ingot tons. The soaking pit equipment is of a rather old-fashioned type while the ingot buggy is very unusual. This consists of an electric locomotive with a man riding in it driving a "trailer" bogie in front of him. The slab mill is obviously destined to undergo a major reconstruction programme in the near future. The strip mill, as originally delivered, was the standard 10 stand mill with four smaller slabbers in front of it. During the time we were there about 200 tons of slabs were being dealt with per hour, and almost exactly 1,200 tons were rolled during the six hours that we were there. Quite a thin slab was used and also a light coil. Here, as elsewhere, extensive use is made of isotope gauges, which are mounted on the housings in the hot mill. The mill is not running at a "fantastic" output. The 66 in. mill at Zaporozhe is, for its age and type, going extremely well, and in the future the whole output of the 10 furnace shop, plus some silicon steels made in a nearby shop and some stainless steel made in electric furnaces nearby will be consumed. To deal with about 36,000 tons of ingots a week is very good.

Coming to the cold mill, the equipment is obviously in a transient stage. Silicon steel, motor-car body sheets, stainless-steel sheets and tin-plate are made in this installation, and this is all done on what to our eyes is rather an unusual plant. There is first a 66 in. three-stand cold reduction mill, an American plant built in 1936. This is preceded by three typical picklers and a special pickler for stainless strip. After that comes a large battery of hood-type annealing furnaces, of which a high percentage are electrically heated. We were told that the silicon steels were being annealed in vacuum. In making tin-plate, the piece is rolled on the three-stand mill; it is annealed, slit into three, and then rolled down on two narrow three-stand mills in pieces having a maximum width of about 15 in. At present sheets no thinner than 0·27 mm. are rolled, but an endeavour is to be made to get down to 0·20 mm. In effect, the plant consists of six-stand reduction with an inter-anneal half way through, but it was stated that this was a temporary phase and that a 1½ metre wide mill was being built in Stalino. The head technical man told us that they reckon that the standard strip mill of the future should be planned for an output of 2,500,000 tons a year of hot strip and on the basis of 40 per cent. flat products and, allowing something for plates, quite a number of strip mills will be built in the future.

TIN PLATE MAKING

One interesting feature consisted in the tin-plate facilities in this plant. There was a twelve-strand continuous hot-dip tinning machine. In fact, there were six of them in a row, and these were tinning quite small coils, weighing about 4 cwt., which were conveyed in coil form to the tin-plate works. No shearing of the tin-plate took place. There was also one narrow electrostatic tin-plate mill, together with processing equipment for stainless sheets.

At Rustavi square ingots were rolled down to 10 in. by 10 in. or 10 in. by 8 in. blooms. We saw a very nicely made blooming mill of Russian manufacture, with a tendency towards the American style, although designed in Russia. It was rolling about 150 ingot tons per hour.

The standard of the steel which we saw at Zaporozhe and at Rustavi was good. We saw very little need for any surface dressing, and, generally speaking, the steel quality was what would be expected from the excellent raw materials employed. To make tube steel, however, is quite a difficult matter, and we were interested to see their inspection methods in the tube plant. We saw two tube plants, at Nikopol and Rustavi, and in those two plants mainly seamless tube was being produced. The tube makers are concentrating on one type; they use Mannesmann piercers, followed by plug mills, and no Pilger mill at all; I believe that there is only one Pilger mill in the whole of Russia. There are also two new electrical-resistance welding plants at Nikopol for small-diameter pipes. I did not see anything which would be regarded as revolutionary in their seamless tube plants, but they were going ahead, and at Nikopol there was a rotary furnace which was charging billets weighing 500-600 lb. at a very fast rate. It was one of the most impressive plants which we saw in the whole of Russia.

CANTEENS AND OFFICES

In visiting all these plants we were naturally interested in general matters in addition to the detailed work; we took an interest in their standard of housekeeping, their canteens and so on. The standard kitchen serving the canteen at a coke-oven plant had a coke-fired stove of a simple nature, and the whole finish of the place was somewhat crude. In the rest-room there were very nice tables and chairs of simple design, but there was no attempt at any polish. Throughout the heavy industry which we saw the machinery was polished, but no money was wasted on fancy doorknobs in the offices or on any of the externals of the plant.

The Russians are obviously very keen on trees. They seem to be able to get trees to grow everywhere in their iron and steel and coke plants, and not just one or two but thousands of them. They have a great deal of grass, but do not ever seem to cut it. There is a certain amount of untidiness in leaving things lying about, but they obviously have the idea that their plants should, if possible, be laid out neatly according to some form of plan. If anything, they tend to be over-spacious. At Nikopol the units are tremendously widely spaced.

It is necessary to remember that we have seen two types of area: the Ukraine, which was devastated, and Rustavi, which has never had any industry before. Obviously what we have seen is very new, and things are changing very fast. We were there only a few days and our impressions must to some extent be conditioned by that fact.

* * *

THE IRON AND STEEL INSTITUTE

Business at the Autumn General Meeting

The annual autumn general meeting of the Iron and Steel Institute was held in London on November 16 and 17. On the morning of the first day, the President, Sir Charles Bruce-Gardner, Bt., who occupied the chair, referred to the deaths, on July 18, of Captain C. A. Ablett, O.B.E., who had been a member since 1908; and, on November 6, of Colonel N. T. Belaiew, C.B.

Turning to forthcoming meetings, the President announced that the Institute's annual

general meeting would be held in London on Wednesday and Thursday, May 16 and 17, 1956. The celebration of the Bessemer Centenary would be held in connection with the annual general meeting and Mr. James Mitchell, C.B.E., a past-president, had agreed to give a lecture on Sir Henry Bessemer and his work and this would probably be delivered on the evening of Tuesday, May 15.

As already announced, a special meeting would be held in France by invitation of the Chambre Syndicale de la Sidérurgie Française and the Société Française de Métallurgie. This meeting would open in Paris on Tuesday, June 5, 1956, and technical sessions held and visits to works paid, in the Paris region, until Sunday, June 10. Following this there would be three alternative excursions to works lasting for some three or four days. The first would be to North-East France, the second to the Lorraine region and the third to Central France.

The autumn general meeting would be held on Wednesday and Thursday, November 21 and 22, during which it was hoped to have the ninth Hatfield Memorial Lecture. The lecturer would be Professor N. F. Mott, F.R.S.

CHANGES IN THE COUNCIL

The President's final pronouncement was to propose, on behalf of the Council, that Dr. H. H. Burton, C.B.E., a vice-president of the Institute and a director of the English Steel Corporation, Limited, Firth-Vickers Stainless Steels, Limited, the Darlington Forge Limited, and other companies, be nominated as President to take office at the annual general meeting in 1956 and to serve for one year. The proposition was seconded by Mr. James Mitchell and carried with acclamation.

On being called upon, the secretary announced the changes which had taken place on the Council since the last general meeting in April, 1955. Mr. W. F. Cartwright had been appointed a vice-president and Mr. W. C. Bell a member of Council. In addition, several honorary members of Council had been elected to serve during their tenure of office as Presidents of societies affiliated to the Institute. They were: Mr. H. H. Utley, President of the Cleveland Institution of Engineers, in place of Mr. H. M. Morgan; Mr. J. F. Smith, President of the Ebbw Vale Metallurgical Society, in place of Mr. H. H. Beese; Mr. C. J. Bushrod, President of the Manchester Metallurgical Society, in place of Mr. J. D. Hannah; Mr. R. L. Willott, chairman of the North Wales Metallurgical Society, in place of Mr. E. Taylor-Austin; and Mr. R. W. Evans, President of the Swansea and District Metallurgical Society, in place of Professor H. O'Neill.

In addition to the above and in accordance with the by-laws, three vice-presidents and five members of Council were due to retire at the next annual general meeting but were eligible for re-election. The vice-presidents were Mr. G. Steel, Mr. I. F. L. Elliot and Mr. N. H. Rollason and the members of Council, Mr. G. H. Johnson, Mr. D. A. Oliver, Dr. C. Sykes, F.R.S., Mr. C. H. T. Williams and Mr. H. Boot.

CARNEGIE SCHOLARSHIPS

The secretary also announced that since the last general meeting, in April, 1955, five Andrew Carnegie Scholarships had been awarded, namely, £200 (second grant) to Mr. A. S. Appleton, and £400 to Mr. J. W. Barton, both of the University of Liverpool; £410 (second grant) to Mr. C. J. Ball and £500 to Mr. L. Stibe, both of the University of Cambridge; and £400 to Mr. G. Sumner of the University of Manchester.

The last announcement made at the business meeting was that 171 new members had been elected and that for the first time in the history of the Institute the number of members on the roll had passed the 5,000 mark. The actual number was 5,004.

At the conclusion of the business, the meeting turned to the presentation and discussion of technical papers. These will be reported in forthcoming issues.

To be continued

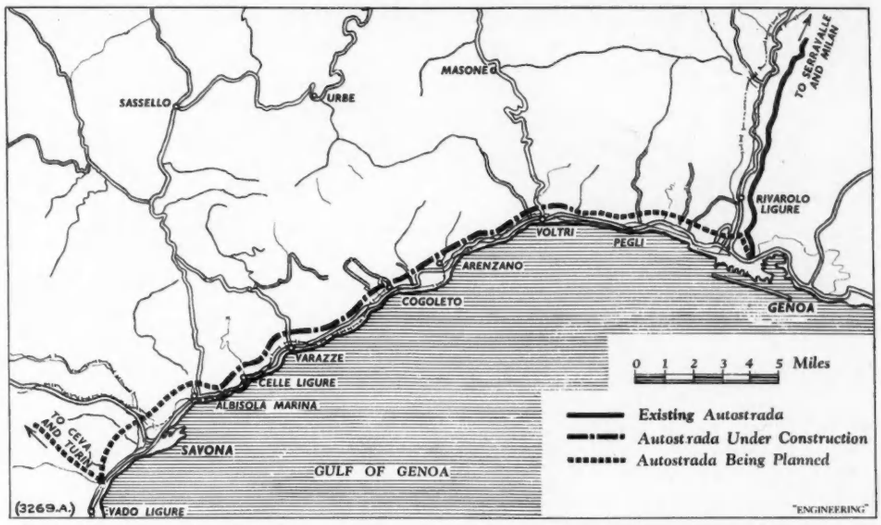

Fig. 1 The autostrada to link Genoa and Savona will join at one end the Genoa-Serravalle autostrada which links Genoa with the Po Valley, and at the other end the projected Savona-Ceva-Turin autostrada.

MOTORWAY THROUGH MOUNTAINS

GENOA-SAVONA AUTOSTRADA

Continued pressure from car-owners and car-makers has so far failed to produce any roads in Great Britain to be compared with the super-highways of the U.S.A., the autobahnen of Germany, or the autostrade of Italy. Lack of capital is frequently cited as the reason for the inexcusable delay; it is therefore interesting to see some of the work that has been done on road-building since the war in Italy, a country much poorer and much more devastated by war than Great Britain.

Before the war the state road network in Italy measured about 12,600 miles; there were also provincial and local roads totalling between 80,000 and 90,000 miles, and 310 miles of autostrade. The Italian autostrade are not so elaborate as the German autobahnen, but nevertheless make an invaluable contribution to the communication system in Italy. The autostrade constructed before the war were: Turin-Milan-Bergamo-Brescia, with spurs to Varese and Como; Padua-Mestre; Pisa-Florence; Naples-Pompeii; and from Genoa northward across the Ligurian Alps to Serravalle. Good communications between the industrial centres of Turin and Milan and the ports of Genoa and Savona are of great importance to the Italian economy. In addition to the rail network there already exists the Genoa-Serravalle autostrada, but the Italian Government have decided that they are going to concentrate on extending the autostrada network of Liguria before anywhere else. They have plans for autostrade from Genoa to Savona, and from Savona via Vado and Ceva to Turin. Work was started on the Genoa-Savona autostrada in 1951, and the section from Voltri to Albisola is now approaching completion.

Fig. 2 Construction of the bridge which will carry the road over the river Lupara, between Voltri and Arenzano. This illustration clearly shows the precipitous nature of the ground.

The route of the autostrada is shown in the map in Fig. 1, which also shows the beginning of the existing Genoa-Serravalle road; the sections at present in the planning stage are those from Voltri to Genoa, from Albisola to Savona and from Savona to Turin via Ceva, the beginning of which is indicated in Fig. 1. The original estimate for the Voltri-Albisola section was £5 million, and the work was expected to last from 1951 to 1956. Communications between Genoa and Savona consisted before 1951 of a single-track railway and the main road, the Via Aurelia. The Via Aurelia between Genoa and Savona is narrow and winding, has eleven level crossings, and becomes particularly tortuous and dangerous when passing through the towns of Voltri, Arenzano, Cogoleto, Varazze, Celle and Albisola.

The first plan suggested to improve the communications along this stretch of coast was to make improvements to the Via Aurelia. It was felt, however, that this would only be a stop-gap measure, and would cause hardship and inconvenience where houses had to be cleared to widen the road. It was decided to build a new road inland and above the Via Aurelia, and to provide connections with the existing road network at only four places. A plan for a road with two carriageways was debated, but it was decided that it would cost too much. The road was therefore designed with a single carriageway having three tracks.

Each track is 11 ft. 6 ins. wide, the whole

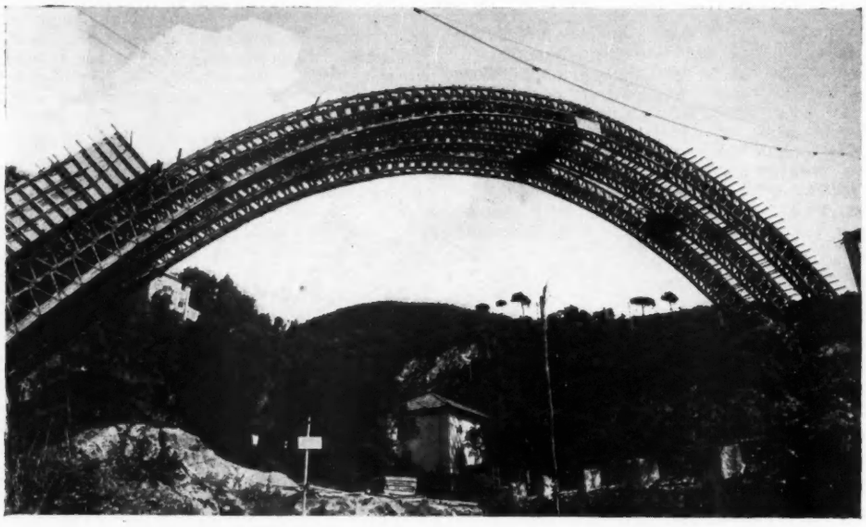

Fig. 3 Construction of the bridge at Varazze, showing the form of centering used. Three arched centerings were erected, and stiffened against lateral movement by light metal beams and tensioned cables. At the left can be seen the shuttering for the reinforced concrete.

carriageway therefore having a width of 34 ft. 6 in. On each side there are shoulders 3 ft. 6 in. or more wide on embankments and 1 ft. 9 in. wide in cuttings. On viaducts and bridges there are two footpaths each 3 ft. 6 in. wide. Gradients are always as slight as possible, and never exceed 4 per cent. In tunnels the gradient is never more than 2 per cent. The radius of the curves is not less than 650 ft., except in one or two places of exceptional difficulty where it is reduced to 500 ft. All tunnels are straight, with a width of 42 ft. and height to keystone of 25 ft. Lay-bys are provided at intervals of about 1¼ miles.

The country traversed is extremely broken and precipitous, as can be seen from Figs. 2 and 3. Of the total route distance of 16 miles between Voltri and Albisola 2 miles run through tunnels and 3 miles over viaducts or bridges. There have also been difficulties with the foundations for bridges, viaducts and embankments, and the retaining walls of cuttings, due to the unexpectedly treacherous nature of the rock formations. There are four stations where traffic can join or leave the road; they are at Voltri, Colletta near Arenzano, Piani di Invrea near Cogoleto, and Albisola. Until the other sections of the autostrada are complete, traffic will use the Via Aurelia from Savona to Albisola and from Voltri to Genoa.

Construction of the road has been carried out by various contractors under the supervision of the Italian Highways Authority, Azienda Nazionale Autonoma delle Strade Statali (A.N.A.S.). Legislation is now passing through the Italian Government to authorise funds to complete the Genoa-Savona autostrada. Other plans for the future include the Savona-Ceva-Turin autostrada and a further possibility is an autostrada linking Milan, Bologna, Florence, Rome and Naples.

CENTERING FOR THE VARAZZE BRIDGE

The bridge at Varazze, shown under construction in Fig. 3, is of interest because of the unusual form of centering employed. The method was developed by the engineering firm Dott. Ing. Eusebio Cruciani, of Rome, and consists essentially of providing centering made from a bundle of thin boards bent to the required shape and then clamped together to form a beam section. For small spans one bundle of boards is sufficient, but for larger spans two or three bundles are used, built up into a girder form, as shown in Fig. 4, by wooden diagonal members.

The Varazze bridge was constructed using three wooden centering arches side by side, each arch being composed of three bundles of boards and the diagonal members. The arches were stiffened against lateral movement by light metal beams and tension cables. The method of erection is to make the lower or basic tier on the ground, raise it into position by the tackle which can be seen above the centering in Fig. 3, and add the upper tier *in situ*. The span of this arch is 330 ft., and the rise 98 ft. Construction of the shutters for the reinforced concrete arches can be seen in progress on the left of Fig. 3; the total volume of concrete to be supported by the centering is 42,000 cub. ft.

The firm of Cruciani claim that the main advantage of their method is that the curvature of the arch can be exactly checked before erection. Other advantages are: there is no supporting framework to be exposed to danger during floods, a relatively little wood is needed, with no special cutting to shape, and it can almost all be recovered and used again. The system is covered by world patents; agents for Britain and the Commonwealth are Approved Inventions, Limited, 177 High-street, Orpington, Kent.

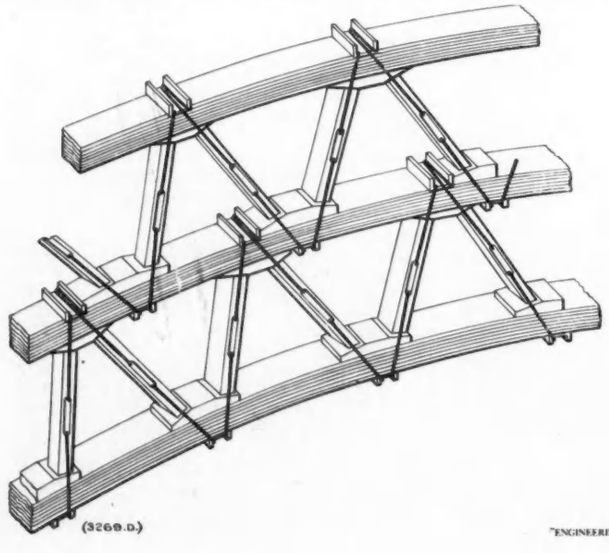

Fig. 4 Detail of the centering used in the constitution of the Varazze bridge. Each beam is made of a bundle of wooden boards bent to the required radius and clamped together. Wooden diagonal members are used to make them into girder form.

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FLUORESCENT LAMP PROBLEMS

In a paper entitled " Some Factors affecting the Efficiency of Fluorescent Lamps—the Quest for Higher Luminous Output," which was read before the Illuminating Engineering Society on Tuesday, November 8, Mr. F. Jackson, Mr. R. Molloy and Mr. K. Scott said that although fluorescent lamps were relatively expensive to install they were being employed in increasing numbers. Users demanded that lamps should last longer and give more light, and as the life and light output of fluorescent lamps were not directly inter-related the makers could satisfy this requirement.

Unfortunately there were many factors which limited progress. The 5 ft. 80 watt lamp, for example, must operate satisfactorily on voltages from 200 to 250 volts, although 70 per cent. were used on 230 volts or over. A slightly longer lamp would work successfully on 230 volts and would be a more efficient light source than the existing lamp. Again, the highest light output of a given lamp was obtained at a specific operating temperature, which was determined by its dimensions, loading and by the ambient temperature. Yet the same lamp was used in both hot and cold locations.

Fluorescent lamps, made under controlled conditions in the laboratory, gave about 4 per cent. more light than those produced in the factory. This was due to the fact that manufacture subjected the fluorescent phosphor to conditions of temperature and atmosphere, which reduced the efficiency with which it absorbed ultra-violet radiation and emitted visible light. As the best phosphors had an efficiency between 80 and 90 per cent. no revolutionary advance was likely, but the maintenance of phosphor efficiency for long periods under the conditions which obtained inside the lamp would gain in importance as the expected life increased.

Although krypton, instead of argon, as a filler gas would raise the light output it would result in a reduced arc voltage. Substantial current increases would therefore be necessary to maintain the voltage of lamps of existing dimensions.

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ELECTRICITY SUPPLY IN OCTOBER

During October, 1955, 5,877 million kWh were sold by the Central Electricity Authority to the English and Welsh Area Boards. This was an increase of 12·4 per cent. over the figure for October, 1954. Allowing for weather conditions and working days, the increase was 9·1 per cent.

The amount of electricity sent out by the Area Boards during the same months was also 5,877 million kWh, of which 151 million kWh were supplied direct by the Central Authority. The increases in the amounts sent out, compared with the corresponding figure in October, 1954, were 9·5 per cent. in the " mainly industrial " areas and 16·6 per cent. in those described as " mainly non-industrial."

THE STRENGTH OF ENCASED STEEL STANCHIONS

PROVISIONS OF THE DRAFT B.S. 449

By F. G. Thomas, PH.D., B.SC., M.I.C.E., M.I.STRUCT.E.*

In recent years, considerable attention has been given at the Building Research Station to the interaction between multi-storey steel frameworks of buildings, the concrete encasement of the members, the floors, and the walls. These interactions are of very great importance in their effect on the behaviour of the framework, both at working loads and near collapse, and allowance for them in design will help considerably in the economic and efficient use of structural steel.

At present, research has not progressed sufficiently to allow comprehensive design rules to be prepared on the basis of the true interaction between all parts of a building (including some parts which are not usually now considered to be structural). However, certain features of this interaction, or composite action as it is sometimes called, are already partially allowed for in design; and it is the purpose of this article to examine one such feature, the strengthening of a steel stanchion by a concrete encasement, in relation to the recommendations contained in the draft revision of B.S. 449, "The Use of Structural Steel in Building," which was circulated for comment earlier this year.

ALLOWANCES FOR ENCASEMENT

The concrete encasement that is considered in this British Standard is clearly intended to represent the necessary protection of the stanchion from the effects of fire in multi-storey buildings, as prescribed by some local authorities. Before the 1948 edition of B.S. 449, the provision of such protective encasement was not accompanied by any increase in the permissible load that the stanchion could carry. Some allowance for the stiffening effect of the concrete was made in B.S. 449 (1948), in which it was specified that the radius of gyration, to be assumed in calculating the minimum slenderness ratio of the stanchions, could be increased beyond that of the bare steel section to one-fifth of the minimum overall width of the encased section (i.e., width of steel section plus twice the specified 2 in. cover of concrete). Since the permissible stress on the stanchion is a decreasing function of the slenderness ratio, this allowance was often appreciable; and those who prepared this Standard thought it desirable to limit the concession by restricting the permissible stress to not more than 50 per cent. above that appropriate to the bare steel section. The 1948 Standard included no allowance for the ability of the concrete to carry direct load.

In the draft revision of B.S. 449 recently issued, allowance for the structural help from the encasement has been taken a stage further by assuming that the concrete carries load over a rectangular area of width equal to the flange width and of depth equal to the mean depth between the flanges, and that the stress in the concrete is one-fifteenth of that permitted in the steel. It is not easy to see a rational justification for this new rule and, before looking further at the practical effect of this allowance, consideration will be given to the primary structural requirements of an encased stanchion.

PRIMARY REQUIREMENTS

Having regard to the purpose of the encasement as usually provided, it appears that the following requirements should be satisfied:—

(1) For the normal conditions of use of a building, the encased stanchion should have an adequate load factor against collapse;

(2) In the event of a fire, the cover of concrete over the stanchion should continue to give protection to the steel for the specified period;

(3) During and after a fire, the stanchion and the core of the concrete should together retain such strength as will ensure a reasonable load factor against collapse.

It may reasonably be assumed, as is commonly done for reinforced concrete, that in a very short encased stanchion, axially loaded to failure, the steel will reach its yield stress and the concrete will attain a stress of two-thirds its cube strength. The ultimate load of an encased stanchion is thus, in general, given by

$$P_{ult.} = \alpha \{ t_y A_s + \tfrac{2}{3} u A \} \quad . \quad (1)$$

where t_y denotes the yield stress of the steel, A_s the cross-sectional area of the steel, u the cube crushing strength of the concrete, A the cross-sectional area of the concrete, and α the reduction coefficient to allow for slenderness of the stanchion.

In order to satisfy the first requirement, the permissible load on the stanchion may be obtained by dividing the ultimate load, as given by equation (1), by a suitable load factor. Alternatively, the permissible load may be derived from a modification of equation (1), replacing the ultimate stresses t_y and $\frac{2u}{3}$ by permissible stresses for the steel and concrete. The ratio of the ultimate stress to the permissible value need not be the same for the two materials. Indeed, it is preferable to adopt a higher ratio for the concrete than for the steel so that the load factor for an encased stanchion increases as more allowance is made for the contribution of the concrete in carrying load.

With the latter method, the permissible load is given by

$$P_{permissible} = \alpha \{ F_t A_s + c A \} \quad (2)$$

where F_t denotes the basic permissible stress for the steel for a slenderness ratio of zero (and is equal to the permissible stress in the steel in axial tension), and c the permissible stress for the concrete in an axially-loaded short member.

For a bare stanchion, and for an encased stanchion satisfying the requirements of clause 21(*b*) of the draft revision of B.S. 449, the reduction coefficient α is equal to the ratio of the permissible stress F_a (corresponding to the appropriate slenderness ratio) to the basic stress for a slenderness ratio of zero.

If, for the permissible stress in the concrete, the recommendations of Code of Practice CP 114 are followed,

$$c = 0{\cdot}253\, u \quad . \quad (3)$$

and equation (2) becomes

$$P_{permissible} = F_a A_s \left\{ 1 + \frac{0{\cdot}253\, u}{F_t} \frac{A}{A_s} \right\}. \quad (4)$$

It will be seen from this equation that the effective modular ratio (i.e., the ratio of the permissible steel and concrete stresses) is $\frac{F_t}{0{\cdot}253\, u}$. For a mild steel stanchion, $F_t = 9$ tons per square inch and the effective modular ratio is

$$\frac{9 \times 2{,}240}{0{\cdot}253\, u} = \frac{80{,}000}{u}$$

where the concrete cube strength u is in lb. per square inch. For the concrete specified in the draft Standard, $u = 3{,}500$ lb. per square inch and the effective modular ratio is 23. Thus for the common example of a mild-steel stanchion encased in concrete of this strength, a logical value for the permissible load would be.—

$$P_{permissible} = F_a \left\{ A_s + \frac{A}{23} \right\}. \quad (5)$$

With regard to the second requirement, the effect of fire on an encased stanchion is initially to set up steep temperature gradients in the protective cover of concrete which tends therefore to crack and spall away from the steel leaving the latter unprotected. In order to increase the fire resistance of the stanchion it is necessary to reinforce the concrete with a suitable binding or wire mesh so that, even though the concrete cracks and separates from the steel, it will remain in position. The requirements of the Standard should ensure that the concrete cover will continue to give protection to the steel so that the stanchion has a fire resistance of at least two hours.

With regard to the third requirement, the load factor for the conditions in a building after a

The strengthening of steel sections by use of concrete casings is being studied at the Building Research Station. Both experiment and theoretical studies are being directed towards procuring the more economic and efficient use of structural steel.

* Senior Principal Scientific Officer, Building Research Station, Department of Scientific and Industrial Research, Garston, Watford, Hertfordshire.

severe fire need not be very high and might perhaps be of the order of 1·25. The load is carried by the steel and only the core of concrete within the steel section; and it is possible that those preparing the draft revision of B.S. 449 had this in mind when proposing that only this core area of concrete should be deemed to carry load. However, if this is so, it would be logical also to base the slenderness ratio on the reduced section, but the draft has retained the increased radius of gyration equal to one-fifth of the overall width of the encasement, as in the 1948 Standard.

Although a series of tests was made some years ago at the Fire Research Station to investigate the fire resistance of encased steel stanchions, the data available are not yet sufficient to enable an accurate estimate to be made of the strength of a stanchion after various periods of fire. It is clear therefore that further research is necessary before a wholly rational method can be introduced for the design of stanchions with protective concrete encasement.

EFFECT OF THE DRAFT REVISION ON PERMISSIBLE LOADS

The proposals in the draft revision of B.S. 449 can lead to important increases in permissible stanchion loads, as shown by the examples in Table I. It will be seen from this table that the concrete can be assumed to carry a direct load of 20 to 40 per cent. of that supported by the steel. The permissible stress on the steel is also increased because of the reduced slenderness ratio adopted to allow for the lateral stiffening effect of the encasement. It follows that the permissible load on an encased stanchion would often be over 50 per cent. greater than the value permitted only a few years ago when the encasement was neglected altogether, were it not that the draft revision of the Standard includes the same restriction as the current edition that the permissible load should not exceed 1·5 times that which would be permitted on the uncased section.

TABLE I.—*Value of Concrete Encasement in Carrying Direct Load*

Steel section, (overall section is 4 in. greater in each direction) in. × in.	Percentage increase in stanchion load due to permitted direct load on the concrete	
	(*a*) According to draft revision of B.S. 449	(*b*) According to equation (5)
18 × 8	37	44
16 × 8	34	43
14 × 8	32	41
12 × 8	28	39
10 × 8	28	41
9 × 7	23	39
8 × 6	26	46
6 × 5	23	49

It has been stated earlier in this note that the new proposals appear to be irrational and it is interesting, therefore, to consider the effect of adopting, as an alternative, equation (4), which has a rational basis. For the particular qualities of steel and concrete considered for the previous figures in Table I, equation (5) applies, and it will be seen from the table that the use of this equation leads to permissible direct loads carried by the concrete encasement of about 35 to 45 per cent. of those carried by the steel.

It would appear from these figures that the proposals in the draft revision are a safe approximation to the direct loads that ought logically to be permitted on concrete encasement provided for fire protection. Nevertheless, it is desirable to modify the Standard to conform with equation (4), because this equation can be used for any size of concrete encasement, and is not limited merely to that with a 2 in. cover, as is the proposed rule in the draft Standard.

This is a matter of some importance, since there are constructional advantages to be gained by designing structures in which a light steel framework for a building is used merely as a skeleton, to be clad subsequently with a reinforced concrete encasement. In such a system, the concrete may carry most of the direct load on a composite stanchion, and equation (4) is applicable to the design of the member.

For more substantial encasements than those now dealt with by B.S. 449 the value of the effective radius of gyration requires consideration. A value of 0·2 times the minimum overall width could safely be used throughout, but for maximum economy this proportion could be increased. It should be noted that if a constant ratio of assumed radius of gyration to overall width is adopted, the reduction coefficient α becomes a function of the ratio of length of stanchion to minimum width, as in reinforced concrete design. The relationship will however be different from that in Code of Practice CP 114 and it would be desirable later to consider the practicability of getting closer agreement between the design of long reinforced concrete columns and the design of long encased steel stanchions.

ACCIDENTAL ECCENTRICITY

The load reductions to be made for slender steel stanchions are based on the Perry-Robertson formula, which has a rational foundation but includes empirical values for some of the parameters. One of these needs special consideration when the stanchion is encased; this is the value of η in the formula. η is a measure of the accidental curvature of a stanchion and/or the unavoidable accidental eccentricity of loading in a supposedly axially-loaded member.

For bare steel stanchions, many laboratory tests have indicated that, on the average, $\eta = 0{\cdot}001\frac{l}{r}$ for a pin-jointed stanchion of length l and radius of gyration r. An upper limit is often assumed to be $\eta = 0{\cdot}003\frac{l}{r}$, and this is the value which was used in the determination of the permissible stresses given in B.S. 449.

For encased stanchions, there is little evidence as to the corresponding value of η to be assumed, and B.S. 449 has made no differentiation in this respect between bare and encased stanchions. This is a matter which cannot very satisfactorily be resolved by laboratory tests, since it is difficult to reproduce practical imperfections in such tests. The starting point for laboratory investigations is usually a study of axially-loaded members with accidental eccentricities, and imperfections such as concrete strength variations, reduced as much as possible. The results of one such series of tests, made by Mr. A. E. Seddon and Mr. R. F. Stevens at the Building Research Station, are given in Table II. The stanchions were all 5 in. by 4½ in. with a 1 in. concrete cover all round, so that the overall size was 7 in. by 6½ in. The proportion of concrete to steel was similar to that of a more practical size of stanchion with the usual encasement for fire protection. Five of the stanchions were tested between knife-edges and the line of thrust was adjusted so that the initial eccentricity of loading, as indicated by strain differences across the stanchion, was as small as possible. The sixth specimen, 1 ft. 6 in. long, was tested between the fixed platens of the testing machine. A view of one of the stanchions at the end of a test is shown in the accompanying illustration.

TABLE II.—Tests on Encased Stanchions with Eccentricity of Loading Reduced to a Minimum

Stanchion No.:	Slenderness ratio of encased stanchion	Reduction coefficient α based on :		Calculated ultimate load (tons) based on eqn. (1) and:		Actual ultimate load (tons)
		$\eta = 0{\cdot}003\frac{l}{r}$ (B.S. 449)	$\eta = 0{\cdot}001\frac{l}{r}$	$\eta = 0{\cdot}003\frac{l}{r}$	$\eta = 0{\cdot}001\frac{l}{r}$	
ED 2	7	0·96	1·00	135	143	156
EB 2	35	0·81	0·97	108	132	140
ED 1	63	0·66	0·93	93	133	144
EB 1	63	0·66	0·93	91	132	135
EC 1	91	0·51	0·69	71	96	131
EA 1	118	0·37	0·45	54	65	105

It will be seen from Table II that the ultimate loads carried by the stanchions were higher than the values calculated for equation (1), even when the values of α were based on $\eta = 0{\cdot}001\frac{l}{r}$ in the Perry-Robertson formula. Using the values of α conforming to B.S. 449 for mild steel (but introducing the actual values of f_y and u) in equation (1), the calculated loads were only just over one-half of the failing loads for the more slender stanchions. The high ultimate loads obtained under the idealised loading conditions of the tests have perhaps no immediate significance for practical design, but provide data on the limiting strengths as a basis for the investigation of the effects of eccentric loading, whether accidental or otherwise.

BENDING OF ENCASED STANCHIONS

The comments so far in this note have been concerned with the axially-loaded stanchion. The strength of an eccentrically-loaded encased stanchion is not easy to calculate, particularly for stanchions with thick encasements.

The draft revision of B.S. 449 does not explicitly specify how an encased stanchion is to be designed when it is subject to combined direct load and bending. By analogy with the rules applicable to uncased stanchions, however, it might reasonably be assumed that members subject to both axial compression and bending stresses should be so proportioned that

$$\frac{P}{P_{permissible}} + \frac{f_{bc}}{F_{bc}}$$

does not exceed unity, where P denotes the direct load on the encased stanchion, $P_{permissible}$ the permissible load in axial compression (as given, for example, by equation 4), f_{bc} the actual maximum compressive stress in the stanchion due to bending, and F_{bc} the permissible compressive steel stress due to bending.

This treatment of combined bending and direct load has no rational basis and the research programme at the Building Research Station includes a comprehensive investigation of the effects of eccentric loading on short and on slender stanchions. This work is limited in the first instance, however, to stanchions with small covers of concrete to represent the usual fire-protection encasement.

Acknowledgment.—The work described in this note forms part of the research programme of the Building Research Board, and is published by permission of the Director of Building Research.

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METALS AT LOW TEMPERATURES

Report on Paris Conference

Various aspects of the effects of low temperatures on metals were discussed at a recent conference in Paris on low-temperature problems and, in order to bring these observations to the attention of metallurgists generally, the metal physics committee of the Institute of Metals has arranged a meeting at the Institute's headquarters, 4 Grosvenor-gardens, London, S.W.1, on Wednesday, December 7, commencing at 6.30 p.m.

After a short introduction by Sir Francis Simon, C.B.E., F.R.S., Professor of Thermodynamics at the Clarendon Laboratory, Oxford, explaining why low temperatures are becoming of increasing importance to metallurgists, Dr. P. L. Smith and Dr. H. M. Rosenberg, of the Clarendon Laboratory, will deliver individual reports on the Paris conference. They will review work on thermal and electrical conductivity, the specific heats of metals, and some of the mechanical properties of metals at low temperatures, such as internal friction, elastic properties and fatigue.

The meeting will be open to non-members of the Institute and tickets will not be required.

POWER RECTIFIERS

TECHNIQUES AND PERFORMANCE WITH GERMANIUM AND SILICON

In an " integrating " paper entitled " Germanium and Silicon Power Rectifiers," presented to the Institution of Electrical Engineers on November 10, the authors, Mr. T. H. Kinman, Mr. G. A. Carrick, Mr. R. G. Hibberd and Mr. A.J. Blundell (all of whom are with the British Thomson-Houston Company, Limited), traced the history and growth of the use of semi-conductors as rectifiers up to the present day. In an appendix, a full theoretical analysis was given. Brief extracts from the paper are summarised below.

Rectification by solids was first observed over a century ago, but it was only in recent years that semi-conductors began to be used, and more recently still that power conversion has been possible. Rectifiers rated at 1,000 kW have been made with conversion efficiencies of over 97 per cent. (ENGINEERING, page 672, *ante*), and an 18 MW installation is being constructed.

Physically, a semi-conductor rectifier consists of two parts, at the junction of which rectification occurs. In one part there are impurity atoms which have one valency electron less than the semi-conductor, and in the other atoms which have one electron more. It is the flow of the free electrons and " holes " across the junction which carries the current. Junctions of this nature which are known as the *p-n* type can be made either by growing a single crystal embodying the two impurities, or by fusing two crystals together. Both are highly efficient as rectifiers, but the latter is easier to make and will carry greater current densities. It is therefore the type preferred for power devices. Both types are shown in Fig. 1.

TECHNIQUES IN PREPARATION

The extreme purity required of the semi-conductor and the need for large crystals have given rise to special techniques in preparation. For example, to make good high-voltage rectifiers of germanium the amount of arsenic present must be less than one part in a thousand million—necessitating great precautions against contamination. The steps taken in producing single-crystal germanium may conveniently be classified under the following headings: extraction of the germanium from natural sources and chemical purification; reduction to the metal; refining the metal to an intrinsic state of purity at room temperature; adding impurity elements; pulling of a single crystal; and methods of control.

There is now an abundant supply in Britain of germanium residues recoverable from flue dust, but it contains many injurious elements that have to be removed. Of these arsenic, referred to earlier, is one. However, the degree of purification achieved by most modern chemical processes falls far short of that required. Improved chemical methods only reduce the arsenic content to 0·25 part per million.

In the reduction of germanium dioxide to metal, the heating cycle in a hydrogen atmosphere is arranged by temperature control to minimise the loss of germanium in volatile products. Reduction occurs at 700 deg. C. and, when complete, the temperature is raised well above the melting point of the metal (936 deg. C.), after which the metal is allowed to solidify and cool over a period of several hours. Zone refining is an advance on the earlier crystallisation method of metal refining. In it, the germanium is placed in a graphite boat surrounded by an atmosphere of inert gas, and is drawn through a series of high-frequency heating coils each of which maintains only a short length of the ingot in a molten state. As the impurities are more soluble in the liquid than in the solid metal, they are slowly swept to one end, which can then be cut off and discarded. (A description of zone refining and crystallisation was given in ENGINEERING, vol. 178, page 312, 1954.) To grow a single crystal, the purified metal is melted and maintained very exactly just above melting point. A seed crystal with its end cut perpendicularly to one crystal axis is lowered into the melt and then withdrawn at the rate of a few inches per hour, being rotated at 100 r.p.m. the whole time. Any thermal or mechanical shock during the period of growth is liable to cause lattice defects which render the crystal unsuitable for rectifier use.

Since the characteristics of the rectifier will be influenced by the resistivity of the crystal, control is necessary. For example, a small percentage of impurity may be added to the charge of metal before melting, and the resistivity of the ingot will then vary along its length because of the increasing concentration of impurities in the molten metal due to segregation. This is overcome by matching the pulling rate to the concentration. When making a fused-junction rectifier, it is now customary to use an *n*-type crystal, and so the impurity to be added to the melt will consist of a very small amount of one of the elements having five valence electrons per atom—for example antimony or arsenic. A *p*-type crystal can be made by adding impurity atoms with only three valence electrons, such as gallium or indium. A junction can be grown as a single crystal by adding to the melt pellets of *p* and *n*-type impurities alternately, or by the method in which both are in the melt together and are segregated by rate-of-growth control, forming alternate *p* and *n* regions.

Cutting the crystal into wafers or slices requires special care owing to the high cost of the crystals. The method using a high-speed rotating disc that has been used for quartz is satisfactory, but becomes wasteful when the ingots are ½ in. or more in diameter. This is because the wheel must be mechanically strong and may approach the same thickness as the slice to be cut (usually about 0·02 in.). Thus about half the material is lost in the cutting sludge from which recovery is expensive. A less wasteful method of cutting has been developed and is shown in Fig. 2. A number of fine tungsten wires, about 0·005 in. in diameter are loaded with fine abrasive dust in suspension. The wires are motor-driven backwards and forwards under tension across the ingot, moving about a foot in each direction and reversing three times a second. Up to 40 slices may cut in an hour by this means.

CONSTRUCTION AND APPLICATION

The basic unit, as shown in Fig. 1 (*b*), may be defined as an assembly common to all types of rectifier so far developed. It is constructed as follows. In general, the semi-conductor will consist of a wafer of *n*-type material, about 0·02 in. thick, with an area proportional to the current rating. The lower surface is soldered intimately to a base material having about the same coefficient of expansion as the wafer, a low ohmic resistance and good thermal conductivity. For germanium, pure indium is a convenient acceptor (*p*-type) element for fusing to the wafer. A pellet is placed on the surface and then fused in an inert atmosphere. As the oven temperature is increased to about 600 deg. C., the indium will dissolve germanium until a saturated solution is obtained. The amount dissolved will depend on the volume of indium and the oven temperature: adjustment of these controls the thickness of the *n*-region and of the forward current characteristics. Some indium will diffuse into the germanium and this will determine the concentration gradient at the junction. After the junction has been made, a shallow depression is etched electrolytically round it to remove surface impurities which might bridge the junction. The rectifier is then sealed in its case, care being taken to avoid contamination from moisture or foreign matter. Sections of two methods of connection are shown in Fig. 3.

The range of germanium power rectifiers includes types with current ratings of from 0·25 to 60 amperes at up to 300 volts. These can be connected in series and parallel to supply

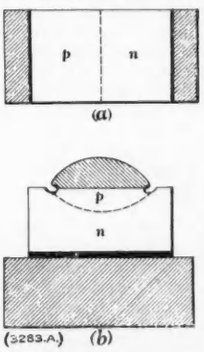

Fig. 1 Rectifying junctions can be produced by growth (a), or by fusion (b).

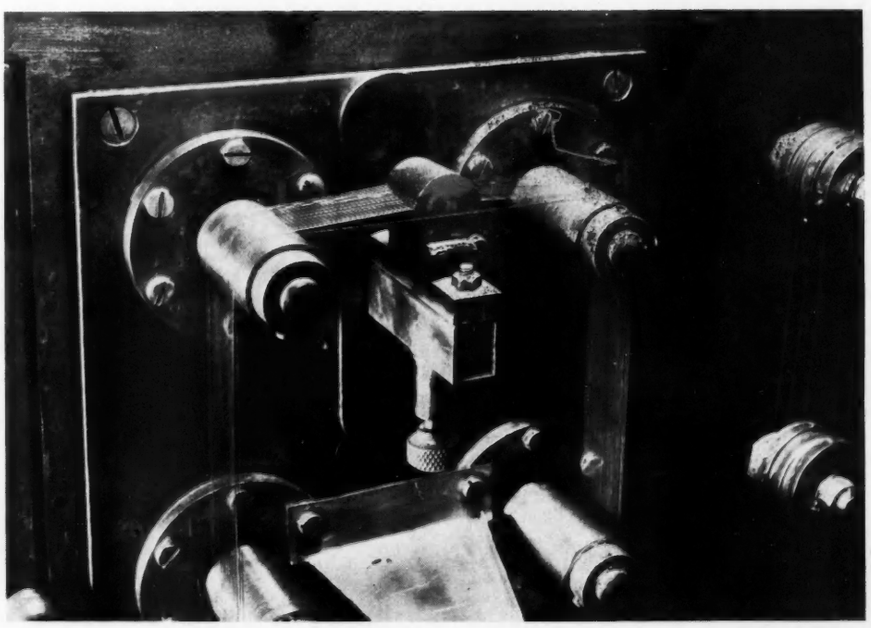

Fig. 2 To slice germanium ingots, reciprocating tungsten wires 0·005 in. in diameter are used.

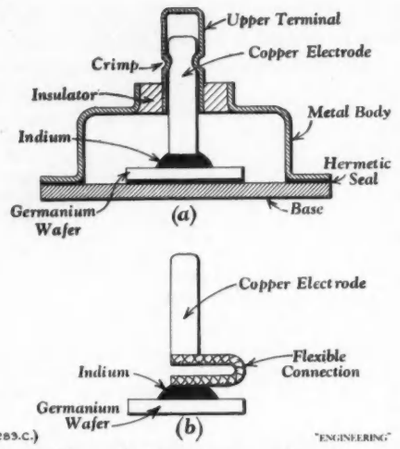

Fig. 3 The sealed junction can either be connected solidly (a) or resiliently (b).

up to 1,000 kW and, as already mentioned, designs are in hand for an 18 MW assembly. The simplest arrangement is a bridge connection across a three-phase supply, but if the ripple is too great, two bridges displaced in phase by 30 deg. can be used. For very large equipments, the number of bridges can be increased giving in effect 24, 36, 48 or 60-phase operation.

For large equipments for use where the ambient temperature does not often exceed 30 deg. C., the units can be cooled by drawing air past the cooling fins; in tropical countries and locations where the air is dusty or corrosive, a water cooling system is necessary. However, a large number of units at different potentials connected by water pipes is not advisable, and an intermediate air stage is recommended. Alternatively, the units can be immersed in a sealed tank of volatile liquid which is boiled by the rectifiers and condensed on the outer walls.

Power losses in the rectifiers are very small: including a cooling fan they probably do not exceed 1·6 per cent. The overall loss, including the transformer circuit, would therefore be only about 3 per cent. Even when working as low as 10 volts and 10 per cent. of full load, the efficiency remains at 90 per cent. This type of rectifier therefore becomes particularly useful for electrolytic and plating purposes, and accurate control can be obtained by various means.

450 H.P. DIESEL LOCOMOTIVE WITH THREE-SPEED GEARBOX

The second of two eight-coupled direct Diesel 450 b.h.p. locomotives has just been completed at the works of Hudswell, Clarke and Company, Limited, Railway Foundry, Leeds, 10. The two locomotives were ordered by the South African Iron and Steel Industrial Corporation, and will be used for shunting duties at Vanderbijl Park near Johannesburg. Each locomotive has a Davey, Paxman engine driving through a fluid coupling and 3-speed gearbox on to the eight driving wheels. The maximum tractive effort of the engine at the one-hour rating is 32,825 lb., and the greatest load it can haul on the level is 1,576 short tons. The fuel tank has a capacity of 250 gallons.

The prime mover is a Paxman 12 RPHL series II Diesel engine. On the continuous rating this engine is set to develop 412 b.h.p. at a maximum speed of 1,250 r.p.m. under site conditions of 4,900 ft. above sea level and 95 deg. F. maximum ambient temperature. The one-hour rating is 453 b.h.p. at 1,250 r.p.m. under similar climatic conditions. The engine is started by a starter motor with a toothed pinion which engages with a toothed ring on the flywheel on the Bendix principle. The starting equipment comprises the motor, a 360 ampere-hour lead acid battery, a gear-driven charging dynamo, an ammeter, a control board, and a starting switch.

The water cooling system is at the leading end of the locomotive. The cooling surfaces of the Serck radiator comprise a battery of gilled vertical tubes bolted with rubber gasket packings to top and bottom headers. The cooling system for engine lubricating oil is incorporated in the radiator. A belt-driven 48 in. axial-flow fan induces draught through the cooling elements, and a bulkhead plate separates the radiator fan from the engine compartment. The circulating air from the radiator is expelled to atmosphere through grilled apertures in the bonnet sides.

CLUTCH AND GEARBOX

A Vulcan-Sinclair scoop-control fluid coupling, size 29, S.C.R. 5, acts as a main clutch between engine and gearbox. The fluid medium in the coupling protects the gearbox from engine torque impulses and vibrations, and also protects the engine from shocks transmitted back through the gearbox from the locomotive road wheels. A control lever operates the scoop tube of the coupling, and is connected to a control lever in the cab by which the scoop can be withdrawn and the drive completely disconnected when the direction gear is put in the neutral position. In normal operation the direction gear clutch is operated straight through without a pause in neutral; the scoop remains in the engaged position and the engine is kept to idling speed.

Incorporated in the fluid coupling are centrifugal valves, which open at idling speed and close when the engine is accelerated. When the scoop is engaged and the engine accelerated, the working circuit of the coupling fills rapidly and the full tractive effort of the locomotive is smoothly and quickly developed.

The fluid coupling also permits a momentary overload torque to be developed, which is sometimes needed to overcome the static friction and inertia of a heavy train. This is achieved by accelerating the engine quickly while the working circuit is filling, so that the full torque of the engine is transmitted together with additional torque due to the flywheel effect of the rotating parts as the engine speed is pulled down by the engagement of the fluid coupling.

Hudswell, Clarke made the gearbox, which provides forward and reverse, three speed-ratios, and low and high range; there are thus effectively six gears in either direction. The change speed mechanism is of the synchro-self-shifting type where the gearwheels are in constant mesh, and an S.S.S. clutch is provided for engaging one or other of the gears as determined by a control lever in the driver's cab. Gear changing takes place on moving the control lever to any one of the three notched positions, without manual regulation of the fuel control. Forward and reverse gears are operated from a hand control in the cab, which can only be used when the locomotive is stationary. The range gear control can also be operated only when the locomotive is stationary.

The lubrication of the final reduction gears and bevel wheels is by splash from a large capacity oil sump. The lubrication of the top spur gears is by spray from a built-in gear pump which supplies filtered oil to gear contacts, and also ensures sufficient lubrication to the bearings. The gearbox is below the shunting platform which is clearly shown at the rear of the locomotive in the accompanying illustration, and it is therefore easily accessible for maintenance.

COMPRESSED-AIR WAGON TIPPING

An auxiliary direct-current generator provides a 440 volt supply of current for a 50 h.p. motor-driven air compressor. The air compressor, which is not incorporated on the locomotive, is used for a compressed air system for tipping wagons.

The auxiliary generator is chain-driven from an auxiliary gearbox situated between the output of the scoop control and the input of the change speed gearbox. By this arrangement the scoop-control fluid coupling is used as a shockless driving unit between the engine and generator when the generator is operating. The auxiliary gearbox has sliding gears for bringing the driving chains into motion when the generator is required to run. The driver's controls for the generator drive incorporate interlocking mechanisms which allow engagement of the drive only when the locomotive is stationary and the direction gear is in the neutral position.

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GAS-TURBINE LOCOMOTIVES

In a British Association paper entitled "The Scientific Development of Modern Locomotive Design," which was published on page 377 of our issue of September 16, reference was made to the Union Pacific gas-turbine electric locomotives. The paper omitted to mention that these locomotives were built by the General Electric Company at their Erie, Pa., locomotive works. A large number of gas-turbine units of similar size have been supplied for locomotive, generator and compressor applications, and over 700,000 hours operational experience have been gained.

Two Diesel locomotives have been built for shunting duties in South Africa. The drive is transmitted through a fluid coupling and a three-speed gearbox to the eight coupled driving wheels. The gearbox beneath the shunting platform at the rear is easily accessible for maintenance.

RESEARCH IN AUSTRALIA

SOME RESULTS OF PRACTICAL VALUE

The Sixth Annual Report of the Commonwealth Scientific and Industrial Research Organisation* is an impressive document of 179 foolscap pages. It presents an account of the research, development, technical advisory work and information services on behalf of Australian industry during the year ended June 30, 1954, sponsored by the Commonwealth Government at a total cost from all sources of close on £5 million. The major Divisions of research now number 16, the latest addition, during the year under review, being the Division of Mathematical Statistics, with headquarters in Adelaide. Its main function is to assist the other branches of the Organisation in planning experiments and interpreting or analysing results. The Division also serves State Departments, universities and commercial enterprises wherever statistical surveys or experimental techniques are appropriate. In addition to the Divisions, there are now 18 independent research Sections, comprising establishments at present of smaller scope but likely to acquire the status of Divisions as their operations expand in magnitude and importance. Probably the next new Section to be created will be concerned with farm mechanisation research, in which subject an exploratory survey is already in progress on the methods in use for conserving grass hay on farms, with special reference to the engineering aspects of mowing and raking machinery, and to the optimum surface shape for scarifier shares.

DETERMINING FUNDAMENTAL STANDARDS

Among the old-established fields of research, some of particular interest to engineers are covered by the Divisions of Metrology, Physics and Electrotechnology which together comprise the Australian National Standards Laboratory. Between them they are responsible for the maintenance and periodical calibration of the primary reference standards, and for the conduct of researches directed towards improved techniques and higher accuracy in all such work. The degree of precision achieved may be inferred from a recent international comparison of four end standards, in which the Metrology Division's interferometric results agreed with those of the International Bureau of Weights and Measures within half a millionth of an inch. Associated research is being carried out on techniques of multiple beam interferometry, which have been used for studying the particle tracks in nuclear emulsion plates, and for measuring vibratory displacements. A multiple-beam interference comparator of 1 metre capacity is under construction for high-precision comparisons of length in terms of light waves.

In connection with standards of mass, one of the most interesting developments is the use of an electrolytic polishing technique for the controlled removal of traces of metal in the penultimate stages of producing precise weights. Adjustment within 10 parts in one million has been achieved in this way with weights as small as 10 grammes. For weighing of the utmost precision a balance of 1 kg capacity has been constructed with means for mechanically interchanging the loads on the pans without the balance case being opened. Inter-comparisons of several groups of standards have revealed that the values of all the weights in regular use have remained satisfactorily constant. For work of this sort a 200 gramme balance has been fitted with stirrups of a modified design suspended from stirrup planes of synthetic sapphire. The performance of the balance is said to be improved by these changes. In the field of the slightly less precise weighing used for chemical analysis, the increasing use of automatic weight-application mechanisms has prompted an investigation into the possibility of standardising the weights in such balances to an adequate order of accuracy without removing them from the balance. A satisfactory procedure for doing this has been developed for one type of analytical balance.

The Metrology Division receives a good many requests from industry, especially for the examination and calibration of materials testing machines. To meet these needs a range of proving instruments is being acquired to enable the largest testing machines installed in the Commonwealth to be calibrated. To calibrate the proving instruments themselves, to an accuracy at least ten times better than that of the testing machines on which they will be used, consideration is being given to acquiring 50 ton and 5 ton deadweight testing machines, probably of similar design to those installed in England at the National Physical Laboratory. Another deadweight machine of N.P.L. type has been constructed for calibrating the hardness test blocks used for checking Vickers and Rockwell hardness machines. A successful device has also been designed for verifying Rockwell hardness machine depth indicators *in situ*. Work is now proceeding on other variable agencies in hardness testing in order that, eventually, it shall be possible for Vickers and Rockwell machines to be completely verified. One of the novelties under investigation is a diaphragm type of indenter load-measuring apparatus employing a capacitance-change principle.

HUMIDITY MEASUREMENTS

Assistance to industry on specific problems as well as general maintenance of standards is an expanding feature of the Physics Division. Among such matters the measurement and control of humidity have recently received special attention, and a new instrument for this purpose has many points of interest. It depends on the principle that if a small ionic crystal is exposed to an atmosphere in which the vapour pressure exceeds that of a saturated solution of the salt, water will condense on the surface of the crystal, forming, initially, a thin film of saturated salt solution. The temperature at which the film remains in equilibrium with the atmosphere, as indicated by the constancy of its electrical resistance, provides an accurate measure of the absolute humidity of the atmosphere. This temperature can be readily determined to 0·1 deg. C. The method lends itself to automatic operation and, with a suitable crystal, may be used for a wide variety of conditions. It also provides an accurate method for determining the vapour pressures of saturated solutions of ionic solids as a function of temperature. For the measurement of moisture content of soils, in connection with consolidated earth structures, three engineering methods have been found capable of determinations, in 5 to 10 minutes, accurate to $\pm$ 0·5 per cent. Field investigations, carried out in collaboration with the New South Wales Department of Public Works, at the Adaminaby Dam site, have demonstrated that methods depending on rapid drying of a sample of soil, or on the reaction of the soil moisture with calcium carbide, are better suited to field practice than methods based on gravimetric determinations of density.

LOW-TEMPERATURE EFFECTS

In addition to the realisation of temperature standards, a good deal of ancillary work is in progress on the production of cells to provide accurately reproducible temperatures intermediate between the primary points on the International Temperature Scale. Sub-standard thermometers are being prepared for intercomparisons of the temperature scales above the " gold point," 1,063 deg. C. Of more than local interest is a series of researches into the physical properties of substances at very low temperatures, for which equipment having a lower temperature limit of 1 deg. K. is available, and is served by a helium liquefier; while a magnet is being constructed for studying magnetic properties near the absolute zero. Temperatures in the range of 2 to 90 deg. K. are measured by hydrogen and oxygen vapour pressure thermometers, combined with helium gas thermometers in an isothermal enclosure. The theoretical connection between the thermal expansion and thermal conductivity of non-metals at low temperatures has been studied, as well as the thermal conductivities of metals in the electrically super-conducting and intermediate states.

FILAMENT LIFE

In progress among a number of researches bearing on the maintenance and reproducibility of photometric standards is an investigation of the seasoning process of tungsten filament lamps, which has been shown to be one of simple recrystallisation of the tungsten filament. During this process the electrical resistance decreases, accompanied by a 10 per cent. decrease in the emissivity of light at all wavelengths. An incidental discovery, in the course of this work, was that standard lamps can be aged at temperatures much lower than those at which they are intended to operate, with the consequent advantages of eliminating blackening and of conserving the useful life of the lamps. An interesting development is the endeavour to improve on the relatively low stability of conventional fixed air capacitors. Some experimental capacitors have been constructed in which all redundant mechanical constraints have been eliminated from the electrode structure. The dielectric medium has been stabilised by sealing the capacitors in an atmosphere of dry nitrogen. The relative values of two such instruments, over a year, have remained equal within 1 part in 10^6 by contrast with capacitors of ordinary design which, even when maintained under laboratory conditions and corrected to a fixed reference temperature, are seldom stable to better than a few parts in 10^5. Another interesting new electrical instrument is a portable bridge that has been designed and constructed to enable the Fisheries Division of the Organisation to measure the temperature and salinity of estuarine waters at depths down to 60 ft. It has proved so successful that similar apparatus is being made to record the same two quantities in the ocean at depths to 3,000 ft.

TITANIUM ALLOYS

From the engineering standpoint perhaps the most topical work in physical metallurgy is concerned with the effects of alloying on the mechanical properties of titanium at temperatures in the range 20 to 600 deg. C. The alloying elements considered were aluminium, tin, zirconium, oxygen and nitrogen, all of which dissolve to an appreciable extent in the α (low temperature) form of titanium and yield solid solution alloys that are stable in the temperature range considered. Subsequent mechanical tests of the alloys have suggested that the effects of aluminium are beneficial at both normal and elevated temperatures. Zirconium has an appreciable effect, while large additions of tin cause intercrystalline brittleness at temperatures above 400 deg. C. Oxygen and nitrogen also tend to make titanium brittle at normal temperatures, without any improvement of strength at high temperature. Some of these influences appear to be due to strain-ageing and the possibilities of delaying strain-ageing by appropriate alloying are therefore being investigated.

CRYSTAL STRUCTURE AND MECHANICAL PROPERTIES

Other researches on metal physics, conducted by the Tribophysics Division, have been concerned with the nature of the energy stored in a metal during deformation. In the case of pure copper, experiments have shown that practically no liberation of energy occurs below the recrystallisation temperature, suggesting that the stored energy that can be measured is associated with dislocations in the atomic crystal lattices. The association of this release of energy with recrys-

* Government Printing Office, Canberra (Price 10*s*. 6*d*.)

tallisation has now been established by hardness, resistivity and density measurements, supplemented by X-ray and metallographic examination. Similar experiments on nickel have shown that about 60 per cent. of the stored energy in this metal is liberated before recrystallisation, and is accompanied by an increase in density and the loss of nearly half the increment in electrical resistivity due to the original deformation. It therefore appears that part of the energy release is due to the disappearance of vacant lattice sites. The remaining 40 per cent. of stored energy is released concurrently with recrystallisation in a manner that, as in the case of copper also, is independent of rate of heating and is not influenced by changing the mode of deformation from torsion to tension.

LATTICE DISTORTION

Various experimental approaches to a fuller understanding of plastic deformation in metals include a study of the changes produced in the X-ray diffraction pattern. The simultaneous distortion of the crystal lattice and the reduction in particle size produce a broadening of the X-ray pattern in which the two contributory effects can be separated by Fourier analysis of the line shapes. This treatment has been applied to nickel filings annealed at various temperatures, in order to correlate the degree of lattice distortion with the amount of stored energy measured directly. Cold working of metals leads to a change of electrical resistivity which a recent, very precise, series of measurements has shown to decrease as the temperature at which the resistance is measured increases. From this result the conclusion has been drawn that the thermal vibration of the atoms is influenced by the lattice distortion introduced by cold-working. The interaction between adjacent crystals in a metal undergoing deformation, and the phenomena of recrystallisation and crystal twinning, are other aspects of metal deformation in course of research. Metallurgical phase changes, diffusion and Martensitic transformations are also being studied.

TIMBER STRESS-STRAIN RELATIONSHIPS

These two objectives also underly much of the work carried out by the Forest Products Division, the materials in this case, of course, being woods and, in particular, the native Australian timbers. Despite the wide range of eucalypts and other species, Australia is not heavily forested, and the most economical exploitation of its timber resources is therefore of great importance. Experimental work is being directed especially to the reduction of waste in forest, mill and factory, and of losses by decay and insect attack. Research of a longer-term character is concerned with the influence of silvicultural treatments on the resulting timber products. Long-term investigations of the structure and chemistry of wood materials are also in progress. Investigations of more immediate application have been concerned, during the year under review, with quantitative measurements of the creep of wood subjected to constant stress, compared with stress relaxation of wood maintained at constant deformation. The main conclusion from these tests is that, to a first approximation, wood behaves like a linear viscoelastic body; whence, it follows, that the response to any loading condition can be predicted approximately if a single relationship, e.g., the creep function, is known.

An interesting observation made during the experiments was that, at high stresses, creep does not occur continuously but as a succession of discrete increments. One series of tests was made on beams of air-dried mountain ash, continuously loaded for long periods. When loaded to three times the design stress, 75 per cent. of the beams failed after two to eighteen months. At twice the design loading 50 per cent. of beams have failed after 2½ to 3 years. The elastic (Young's) modulus in bending was found to increase somewhat with time under load. Observations on green, as well as dry, mountain ash, under either continuous tensile or compressive stress, have confirmed that creep continues for at least 3 years in tension and for a year and a half in compression, the increases in strain being slightly larger for green wood than for dry. No creep has been observed in dry compression specimens held for 18 months under stresses of less than 10 per cent. of the short-time strength. Creep does occur, however, in tension and bending at these low values of stressing. The possibilities of making use of wire resistance strain gauges on wood in this type of experiment has been explored by some trials of printed foil gauges glued with various types of epoxy resin adhesives. A 5 in. single-strand wire gauge has been developed for tests on beams, to check the movement of the neutral axis during prolonged loading.

An attempt to establish an empirical formula for the relationship between the impact strength of wood and its moisture content has not been successful. On the other hand, hardness measurements of wood, made by the Janka method and by a falling-ball technique, have given values that are closely correlated with one another and with the densities of the woods. A start has recently been made on the analysis of the results of loading tests on wood tension joints embodying split-ring connectors and shear plates. These tests have been in progress throughout the past nine years. Another series of long-duration trials is in progress on wood columns of mountain ash, yellow stringy bark and Douglas fir. The scope of this work covers three slenderness ratios and three degrees of eccentricity, loading being constant in all cases. To date, failure has occurred in 102 of 125 columns loaded to 70 per cent. of their estimated short-time failure load. In the 60 per cent. loading group, 39 out of 68 have failed; while in the 50 per cent. loading group, 12 out of 25 have failed. A suggestion, from these trials, that the more slender columns survive for longer periods than less slender ones is to be further investigated.

WOOD PRESERVATION

Much of the Organisation's work in connection with timber preservative treatments is of interest to engineers who encounter similar problems in improving the service life of railway sleepers, poles carrying overhead lines, and fences. In Tasmania, untreated sleepers have been examined in 42 localities and found to have a life at present of about 11 years only, the principal causes of deterioration being mechanical galling at the rail seat combined with decay. Pressure treatment with oil preservative is therefore considered to be economically justified, provided that care is taken to use a preservative that is suitable for the wood species. Comparative tests of mountain ash and *Radiata* pine, for instance, have shown that species exerts a considerable effect on the permanence of certain water-borne preservatives. Some *Radiata* pine tram sleepers treated with creosote, on the other hand, have been in service at Ballarat since 1936, and are performing better than durable eucalpyts in comparable sites. In the Melbourne metropolitan railway system some treated sleepers of New Guinea mangrove wood are behaving well, though they have been only a few years in service as yet.

The Forest Products Division has a high-pressure impregnation plant, which is used for trials on the Victorian Railways of eucalypt sleepers treated with various preservatives. Concurrently with this work on sleepers, attention has been directed to the failure of cross arms on telegraph poles and to the development of preservative methods and equipment for use on fencing posts. To meet the special requirements of Post Office lines and fences in outlying areas, several new treatment plants distributed at distances from towns are projected, while simple, portable equipment has been designed for treating round fence poles. Methods of making wood resistant to termite attack are also being actively investigated. A particularly important problem of this sort arises from the destruction by termites of plywood intended for use as flooring. From tests of several chemicals for momentary dip treatment, two solutions—one containing sodium pentaborate, the other a mixture of zinc chloride and arsenic pentoxide—have proved conspicuously successful. Further experiments with these and other pesticides are therefore being made to determine the concentrations necessary to prevent attack by boring insects, especially the *Lyctus* beetle, on the seasonal sapwood of susceptible timbers.

ARTIFICIAL SEASONING

Close contact with the timber industry is maintained in a variety of studies into improved techniques of artificial seasoning. Techniques of drying by superheated steam and mixtures of air and superheated steam are the subjects of experiments to determine the optimum kiln conditions in respect of temperature, humidity, and gas velocity relative to the species and condition of the wood under treatment. Useful progress has also been made in the development of kiln equipment for conditioning veneers, and the design of pre-driers for timber of large sizes. Other research on veneers, and associated glueing problems, serves an Australian industry that is rapidly expanding in size and importance. The work has included studies of cutting methods for peeled and sliced veneer, and the development of laminated railway sleepers, a hand-operated glue spreader, and adhesives for floor blocks.

Special attention has been directed during the past year to means of increasing the utilisation of wood for packing cases, which has latterly been suffering from competition by other materials. Recommendations covering seasoning practices, the prevention of sap stain and the use of cement-coated or processed nails, have assisted materially in the design of cheap, yet satisfactory cases for the export of fresh and dried fruit, and of a specially lightweight case for the transport of clothing for the armed services. Another series of timber utilisation researches is concerned with the interesting problems of converting sawdust into a substance capable of improving soil. Field trials have been made with hydrolised sawdust, which has been found to induce nitrogen shortage where the nitrogen content of the soil was initially very low, but to delay growth of pasture, although the recovery evident by the autumn following the application was quicker than in a comparable area where the soil was treated with fresh sawdust. Methods are being sought for using micro-organisms to decompose rapidly the non-lignin portions of finely divided wood waste, leaving a residue suitable for soil improvement. Preliminary work has been carried out with wood-destroying fungi for which the optimum conditions of their growth and for the decomposition of mountain ash sawdust have been experimentally studied on a small scale. Another potential outlet for sawdust has been opened by some trials in which fresh grapes packed in sawdust were stored for some time at Sydney and then exported to Singapore, where their condition on arrival was as good as that of similar grapes packed in granulated cork.

RUPTURE THEORY FOR CONCRETE

The efforts of the Forest Products Division towards improving the effective uses of wood for constructional purposes has enabled the Building Division to devote its attention primarily to materials such as concrete, clay products and plaster. A number of fundamental investigations of these types of material include a study of the mechanism of failure of concrete under load. A tentative theory of rupture has been formulated, in which the criterion of failure is a function of the shear strain energy per unit volume and the volumetric expansion. Failure is taken to be the stress at which cracking starts, although this is much lower than the stress under which concrete will break, as distinct from showing incipient cracks. Related to this theory of rupture, a study has also been made of the stresses in and around an inclusion of one elastic substance in a matrix of another elastic material. The conclusions have a bearing on the effect of the properties of coarse, lightweight aggregate on the strength of concrete. Practical confirmation of theories has been sought by

experiments on concretes made with fired shales and other expanded aggregates. The manufacture of such concretes has shown that, while the workability is enhanced by increasing the proportion of large particles, some fine material of less than 52 mesh is necessary to prevent segregation. An unexpected effect observed in concretes made with perlite aggregates is the tendency for lean mixes to expand after a time, possibly due to the presence of soluble silica or zeolitic minerals in the perlite. Another lightweight aggregate under investigation is cellular calcium silicate. For this material at a dry density of 65 lb. per cubic foot, cured by autoclaving for 4½ hours at 350 deg. F., a compressive strength around 8,500 lb. per square inch can be obtained at an age of one day.

The strength of the bond between reinforcement and one-day old concrete has been investigated on the grounds that this property may influence the cracking of pre-cast concrete products. By means of wire resistance strain gauges, attached to the reinforcing wires prior to the casting of prestressed concrete beams, it has been possible to measure the stress initially applied to the wires, the loss of stress due to vibration of the concrete during pouring, the change of stress immediately following the severing of the ends of the wires, and the loss of stress due to creep and shrinkage of the concrete over a period of several months after manufacture.

Research of a fundamental character on plaster has been concerned with the relationship between the precipitation conditions of synthetic gypsum and its behaviour during hydration; and also with the variations in the setting times of plasters retarded by additions of citric acid. The effects of particle size on the setting time of plasters are associated to some extent with the mode of operation of plants handling plaster in bulk by screw conveyors or bucket elevators, and are being studied with special reference to this practical aspect. Tests on commercially-made pre-cast wall units of reinforced gypsum have revealed a tendency towards creeping deflection under continuous loading for several weeks. Other experiments have shown that the diffuse brown discolorations on fibrous plaster decorated with water paint, previously attributed to hydroxide of iron being leached to the surface by alternate wetting and drying of the plaster, can be prevented by the addition of 1 per cent. of lime to the plaster, even when appreciable quantities of iron compounds are present.

ROOFING LIFE

Observations of terra-cotta roofing tiles in an urban atmosphere at Melbourne and in a marine atmosphere near the sea fronts of Victoria, have established the negative fact that deterioration is not primarily due to salt, but have not revealed the principal positive causes and the investigation is therefore being extended to include chemical and mineralogical studies of various tile materials. Examination of the rheological properties of air-blown bitumens of the kind normally used for roof bonding in Australia has indicated that the more highly blown bitumens, of relatively high penetration, may be the most suitable. Other trials with bitumen roof membranes have established that solid bonding of the membrane to the roof deck does not present any greater risk of the membrane being broken, if cracks open in the concrete deck, than is the case when the membrane is laid loose. If, however, the bitumen membrane is built up with overlapping lengths of felt, it has been found that spliced joints between adjacent edges of felt give the membrane improved flexibility by allowing shear in the bitumen between the laps. In a related series of trials, waterproof membranes of a sprayed vinyl resin, of the types used for "Cocoon" or "Liquid Envelope" storage packagings, have been exposed out of doors for six months to explore their suitability for use on walls and floors. The outdoor specimens have shown no signs of deterioration, while a similar membrane in the laboratory has successfully withstood over 4,000 hourly cycles of stretching and recovery through 0·06 in. over a quarter-inch gap.

Other aspects of building research are exemplified by long term studies of the thermal properties and "comfort" of house floors, and of the acoustics of buildings, for which purpose a quarter-scale model of a room is used for experiments.

FUEL RESEARCH AND SOLAR HEATERS

The Organisation's fuel research programme is at present confined mainly to coal in order to investigate the properties and other characteristics of Australian coals, and hence to develop the best and fullest uses of all available native fuel resources. Current work includes research on the engineering aspects of the gasification of low-rank coals, and extensive studies to accumulate accurate and systematic data on the ignition, burning, coking, and gas-making qualities of all the principal indigenous seams now being worked. The properties and modes of utilising coal tars are also under active experimental investigation, special attention being given to improved methods of chemical analysis. For some years work has been in progress on the production of synthetic methane from brown coal and brown coal chars by steam-oxygen gasification in a fluidised bed reactor. A method has now been devised to facilitate this work by measuring the degree of homogeneity of the solids-gas mixture in a fluidised bed. Associated with the researches on coal is a series of trials on the performance of a flat-plate solar absorber. Studies of a prototype have indicated that, for use under Australian conditions, the flow conditions in the absorber and connecting pipework are of critical importance in the efficiency of heat transfer. After allowance is made for the capital cost of the installation, a solar heater for water promises to be economically attractive compared with other forms of heating, up to a temperature of the order of 135 deg. F. which is adequate for many domestic and industrial purposes. The efficiency of the absorber falls rapidly above this temperature, however, and this form of solar heater is unlikely to be economical for general purposes except where other means of heating are far more expensive than they are at present.

UPPER-AIR EFFECTS

Some of the most interesting of the Organisation's present research is concerned with radio- and extra terrestrial-physics, and with related aspects of meteorology in which radio and radar techniques are playing an increasingly valuable part. Under the first of these heads, one of the principal developments is a method, proposed for navigating long-range aircraft, in which synchronised pulse transmitters are located at each end of the flight path. The distance of the aircraft from one terminal station is determined by comparing the arrival times of the two sets of pulses at the aircraft. Since the distances measured are such that propagation via the ionosphere is involved, a knowledge of the characteristics of oblique-incidence propagation over long distances is an essential prerequisite. To test the conclusions of the system-analysis and to provide information on the instrumentation necessary for the ground stations and aircraft, an experimental model of the equipment has been set up on a coastal site between Sydney and Townsville. Another promising radio application is a device that makes use of the radio-Döppler effect for measuring the speed of road vehicles.

Fundamental radio research has been directed to the morphology and theory of ionospheric processes, and to the movements in the atmosphere at ionospheric heights. The storm morphology in the ionosphere probably exerts an important influence on the disruption of long-distance communications during ionospheric storms, and enough is now known of the subject to enable specific remedial measures to be taken. The importance of better knowledge about upper-air movements derives directly from their effects on aircraft and projectiles, and indirectly from their relation to meteorological conditions in the lower atmosphere. To keep in the forefront of experimental technology, a group of investigators are making equipment for purifying semi-conducting materials and for growing single crystals of germanium suitable for use in the development of transistor circuits.

RADIO-ASTRONOMY

The topical announcement of the Organisation's observations of radio emissions from the planet Jupiter is one outcome of long-term research that has recently been concerned with ionospheric absorption and the spectral characteristics and variations of the scintillations from radio stars and discrete radio sources. Analysis of a long series of observations on four discrete sources has shown that the amplitude of the scintillations varies both seasonally, with minima near the equinoxes, and diurnally, with minima near dawn and sunset. These results are at variance with those derived in the northern hemisphere, thus suggesting that both the E and F layers of the ionosphere may contribute to the scintillation. The identification of discrete extra terrestrial sources of radiation demands pencil beam aerials of high angular and aperture discrimination. The steerable parabolic aerial now being constructed in England at Jodrell Bank is intended to meet these requirements; in Australia an effective pencil beam has been evolved at very much lower cost by the use of two long, thin arrays, in the form of a cross. This system is extremely efficient at the wave-length for which it is designed but, unlike a paraboloid, is unsuitable for multi-frequency observations. A cruciform aerial with arms 1,500 ft. long has been erected near Sydney. It operates at a wavelength of 3·5 metres and has a beam width of ¾ degree.

Among some newly-discovered sources of radio emission are the Cloud of Magellan, one of our nearest external galaxies; and a strong source which is almost certainly the nucleus of our own galaxy. The size and shape of three exceptionally strong sources in the constellations of Taurus, Virgo and Centaurus have been studied in detail and found to correspond closely with those of the visible nebulae with which they are identified. The only line emission from our galaxy, so far detected, is that from atomic hydrogen at a frequency of 1,420 Mc/s. Search for the analogous deuterium line, at a frequency 327·4 Mc/s, has been unsuccessful. A survey of the distribution of atomic hydrogen over the Magellanic Clouds has revealed that each cloud is rotating, thus providing information on the masses of the clouds.

For an investigation into the nature of radio waves from the sun the Radio Physics Division uses a highly-directional interferometer, with which the sun's disc can be scanned in two directions at right angles; and also a wide range radio-frequency spectrograph. With the latter apparatus it has been discovered that the transient solar disturbances known as outbursts and isolated bursts radiate at a fundamental frequency accompanied by a second harmonic component. Another important discovery is that it is the rule, rather than the exception, for isolated bursts to show a far more rapid drift towards lower frequencies than is the case with outbursts. These observations suggest that a plausible source of solar radio is plasma oscillations excited in the corona whenever a cloud of corpuscles is ejected through it. The indications are that the sun intermittently ejects clouds of particles, at about one third the speed of light, which may be connected with the origin of cosmic rays.

PRACTICAL METEOROLOGY

It will be appreciated that the foregoing examples of the Organisation research represent only parts of much wider programmes covering the agricultural and pastoral industries that are still of predominant importance, notwithstanding the rapid increase of mechanical industry in the Commonwealth. Research, often of a long-term character, is being actively pursued, not only in connection with crops, fruit, sheep, cattle and fisheries, but also in associated subjects such as soils and irrigation, animal health and nutrition, food preservation, wool textiles, plant fibres

and the development of mineral resources. Not unexpectedly, in view of the intimate relation between weather and food production, the Australian meteorological service is highly developed and served by some first-rate research on weather problems, many of which are of more than local importance. A long-term investigation, for example, is in progress into the transfer of heat and water vapour from the ground surface to the atmosphere, with which is associated the frictional influence of the ground on wind. Its results are furnishing data about natural evaporation from natural and cultivated land, and about the influence of turbulent atmospheric movements on the diffusion of dust, factory smoke and flower pollens in the air near ground level. To facilitate the application of this new knowledge to agricultural problems, oscillograph techniques of measuring micro-turbulence are in use, while electronic instruments to give direct readings of evaporation are in course of design. Also in active progress are physical researches into the meteorological conditions that promote rain, supplemented by experiments in rain making by the use of solid carbon dioxide and silver iodide; in which connection it has been concluded that the effective life of silver iodide crystals is critically dependent on atmospheric temperature and pressure, and that their value is negligible unless they are released at a sufficiently low temperature. To be effective, therefore, silver iodide smoke must be released from an aircraft at altitudes dictated by the height of the clouds which it is hoped to precipitate as rain.

As a final example of practical meteorology, mention may be made of experiments made with large fans mounted some distance above ground level to pull down warmer air in order to prevent damage to orchard fruit during frosty weather. Recent tests with a 12 ft. diameter airscrew at various angles of tilt have established that the best results are achieved when the air stream is directed at about 15 deg. below the horizontal. This is only one of a great number and variety of examples of the ways in which the Organisation's researches in the basic sciences are being used for the benefit of Australia's traditional industries. In the case of the newer, what may be grouped under the general head of mechanical, industries, the value of even the longer-term investigations is often more immediately apparent. The steadily increasing volume of consultation work in connection with specific problems submitted by commercial undertakings is evidence that the Organisation's work is appreciated in the Commonwealth as highly as it is respected by scientific workers in other countries.

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MEMORIAL BUILDING FOR I.MAR.E.

On November 16, 1955, H.R.H. The Duke of Edinburgh, K.G., laid the foundation stone of the Institute of Marine Engineers' National War Memorial Building. This building will house the Institute mainly on the first and second floors, with an entrance vestibule on the ground floor and certain offices on the third floor. It will occupy a site bounded by Fenchurch-street, Mark-lane, London-street and Railway-place, and will contain various other offices, some of which will be let to other companies connected with the marine industry.

The building serves as a memorial to the 3,458 marine engineers who gave their lives in the 1939-45 war. At the luncheon which followed the stone-laying ceremony tribute was paid to the late Mr. Alfred Robertson, for many years honorary treasurer of the Institute, for the untiring efforts he had made towards the realisation of the Institute's new building, both as a memorial and as a home. The Marine Engineers are the only technical institute who have their home in the City of London, and they are also the only technical society whose buildings have been completely rebuilt since the second World War.

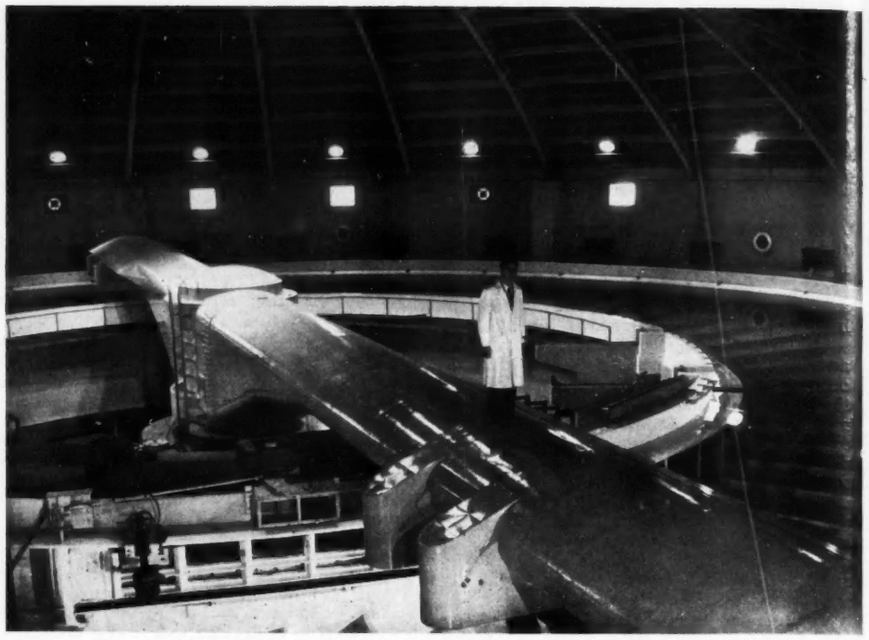


Fig. 1 The 122 ft. diameter rotating beam and 1,000,000 gallon annular tank, here seen empty. Large models can be towed in this 15 ft. deep tank at speeds up to 100 knots. The domed roof, based on a steel structure, is nearly 160 ft. in diameter, which is larger than St. Peter's, Rome.

UNDERWATER HYDRODYNAMIC RESEARCH

NEW ADMIRALTY LABORATORIES

The design of underwater bodies and projectiles has, up to the present, been based mainly on mechanical engineering requirements and not on knowledge of how the body form affects underwater performance. The field of underwater hydrodynamics is, in fact, virtually unexplored, and to remedy this deficiency the Admiralty decided in 1948, to provide comprehensive facilities for such research at the Admiralty Research Laboratory, Teddington. The new laboratories, which have now been in operation for about a year, house unusual equipment of a type which, the Admiralty say, does not exist anywhere else in the world.

The most spectacular item of the new equipment is a 60 ton rotating beam and annular channel which has been designed to investigate the behaviour of full-scale bodies moving at high speed under water. In addition, there are two water tunnels, which are analogous to the wind tunnels used in the aeronautical field for investigating the fundamental behaviour of aircraft. Propeller tests can be carried out in both the rotating beam channel and the large water tunnel, generally in conjunction with the associated model body. Power for the propeller drives will be high-frequency alternating current, and motor-alternator sets for these supplies are at present in course of manufacture. There is also a glass-sided water-entry tank for investigating the problem of the entry of model missiles from the air into the water.

Detailed schemes and layout for these new facilities were worked out by the Royal Naval Scientific Service in conjunction with the Ministry of Works, and many architectural and engineering problems had to be solved during the course of design and erection. Work on the main building contract was begun in December, 1951, and all the buildings were completed and the plant was in a running condition by August, 1954, just in time for a conference on Underwater Ballistics, which was held jointly by the United States Navy and the Admiralty at the new laboratories in September, 1954. The total cost of these new facilities was just over one million pounds, divided almost equally between the plant and the buildings. The main building contractors were Richard Costain, Limited, and for the engineering of the water tunnel and rotating beam, Costain-John Brown, Limited. The electrical plant was supplied by the English Electric Company, Limited.

ROTATING BEAM CHANNEL

Measurements of pressure distribution, drag, side force, yawing moment and pitching moment can be made on large models or full-scale projectiles, up to 20 ft. long, in the annular channel which is traversed by the large rotating beam (Fig. 1). The latter has an overall span of 122 ft., and a mean working diameter of 100 ft. The channel is 34 ft. wide and 15 ft. deep.

The underwater models are secured to struts which are clamped to attachment saddles provided at each end of the beam. Provision is made for attaching the models at radii of 45, 50 and 55 ft., and at various depths in the water. The maximum speed of the beam is approximately one rotation every two seconds, giving a speed to the model of approximately 90 knots at a radius of 50 ft., and 100 knots at 55 ft.

The rotating beam consists essentially of two symmetrical arms attached to a central hub, the whole assembly rotating about a fixed king post (Fig. 2). The centre post and drive assembly is situated on the central island of the annular channel. It comprises a large fabricated steel bedplate on which the king post is mounted, together with the driving motor brake and gearbox. The king post is a cylindrical steel structure carrying the beam hub in two 6 ft. 9 in. outside diameter taper roller bearings, believed to be the largest yet made.

The arms are of rectangular cross section at the hubs and taper to an elliptical section for the portion spanning the channel. They are of stressed-skin construction in steel, the skin plate being welded to a frame and stringer assembly.

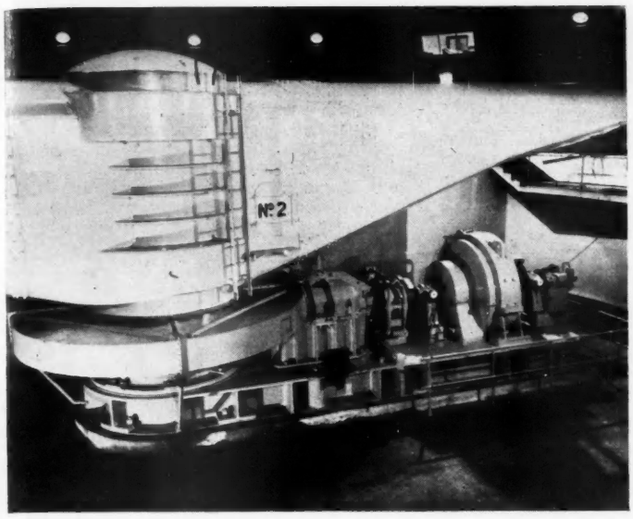


Fig. 2 The kingpost and drive motor for the 60 ton rotating beam. Speed can be controlled to within ± 0·1 per cent.

This form of construction was developed to give maximum rigidity in relation to the weight and air resistance.

The beam, which weighs about 60 tons, is driven by a direct-current motor, through a gearbox and a large gear wheel integral with the centre hub. This driving motor is rated at 1,510 h.p. and is designed to give 1,900 h.p. short-time rating. It accelerates the beam from standstill to a maximum speed of 150 ft. per second at 50 ft. radius in 45 seconds. The motor is fed from a Ward-Leonard set, the speed being electronically controlled to within 0·1 per cent. of maximum speed. The beam is stopped both by regenerative and electromechanical braking, and in an emergency can be brought to rest in 25 seconds.

Automatic control of speed, acceleration and deceleration is brought about as follows: a closed-sequence servo control is used with a speed signal taken from the high-frequency tacho-generator driven by the main motor, and with provision for an alternative water-velocity signal from special Admiralty equipment. A compound signal is available, if required, whereby the tacho-generator signal is modified by the water-velocity signal. The high-frequency tacho-generator is a precision instrument specially developed for accurate speed control applications. It operates on the inductor-alternator principle and has a magnetic rotor without any windings, commutator or brushes. In this way, brush-drop irregularities are avoided and an output voltage proportional to the tacho-generator speed is achieved without regular skilled maintenance. The high-frequency output from the tacho-generator is rectified and compared with an accurate reference voltage obtained electronically. The resultant error, if any, is amplified and fed into the field of the generator control exciter. Stabilising feedback signals are obtained from exciter volts and generator volts through differentiating circuits.

Current limiting is incorporated in the circuit to control the rate of acceleration and decleration so that the Ward-Leonard loop is never overloaded. An emergency stop push-button is provided, and when this is operated, the current limit value is increased to permit maximum regenerative braking current. A voltage relay is used to de-energise the brake " hold-off " solenoid when the rotating-beam motor speed has fallen to a low value. This brake is also used during the later stages of the normal shut-down sequence.

The Ward-Leonard motor-generator set is situated in a plant room adjacent to an 11 kV switchgear sub-station. The main generator of this set is arranged for separate excitation from a control exciter, and is rated for an output of 1,206 kW 600 volts direct current. The set is driven by a salient-pole synchronous motor rated 1,720 h.p., unity power factor, 1,000 r.p.m., supplied at 11,000 volts, three-phase, 50 cycles. The motor is arranged for reduced voltage starting by the reactor method with a manually-operated class OLX circuit-breaker to short-circuit the reactor at the completion of the starting sequence. Three flexibly coupled exciters complete the set, one at the non-driving end of the synchronous motor for the motor excitation and two at the commutator end of the main generator. One of these is the constant voltage exciter for supplying the direct-current motor field and control circuits, and the other is the generator field-control exciter referred to above.

The forces on the model are measured by electrical resistance strain gauges, the signals from which are transmitted along the beam by cables to a number of mercury pick-up troughs and slip rings, thence to the control room where these signals can be read and recorded. The complete control of the beam, other than the starting of the Ward-Leonard set, is carried out from a specially designed desk located in the control room. From here the whole of the channel can be viewed. Access to the central island and to the model-carrying gantry for attaching the models, is by way of an electrical-operated retractable bridge.

160 FT. DIAMETER DOME

The rotating-beam channel installation is housed at the west end of the new laboratories, in a structure of contemporary design roofed by a dome approximately 160 ft. in diameter. With the exception of the Dome of Discovery—a temporary structure—this is believed to be the largest domed structure yet built, comparing with the 112 ft. diameter dome of St. Paul's and the 139 ft. diameter dome of St. Peter's, Rome. The annular channel holds over one million gallons of water which is specially treated and filtered to enable high-speed photography to be carried out on the test bodies which are running in the channel. The overall clarity of this water is so good that objects up to 100 ft. away in the water can be clearly seen. There are two large underwater observation chambers fitted with large thick glass windows through which the experiments can be observed and photographed.

The water is circulated through a filtration plant and enters the water channel through a system of inlets around the inner wall. It returns via overflow outlets in the outer beach, discharging into a common annular collecting duct. Water disturbances in the annular channel are reduced by a sloping concrete beach projecting from the walls at water level, and a series of vertical baffles at intervals around both sides of the annular channel. These baffles are of an aluminium frame construction with infilling of greenheart and elm timber. Precast concrete baffles on stools alternate with the vertical baffles radially across the floor of the tank. All the underwater concrete and metal surfaces are treated with chlorinated rubber paint.

The observation rooms are fitted with window frames and sub-frames of machined zinc-coated mild steel, glazed with 1¼ in. thick laminated toughened glass in panels 3 ft. 2 in. by 2 ft. 6 in., bedded in rubber and sealing compound. To limit any element of risk to personnel in the event of accidental breakage, the observation windows are fitted with bronze roller shutters designed to drop in two seconds to reduce water flow. These shutters are actuated automatically by the breakage of fine wires which are cemented to the window panes.

The dome roof is supported on light steel latticed trusses placed radially, with hinged bearings from the steel tension ring at the springing. Transported in halves, the trusses were welded together on site and erected on a temporary central tower, removed on completion.

Permanent shutters of plywood faced with sapele were used to form the reinforced concrete supporting ribs and to give a warm lining to the roof to minimise condensation. Lightweight thermal insulation is provided by 2·25 in. thick granulated cork concrete, screeded with cement and sand, and finished with three-layer bitumen felt mineralised grey externally. Heating is provided primarily by radiators located around the periphery wall, and by a system of copper heating pipes ringing the whole of the dome soffit. The balance of heat requirements and the control of the level of humidity in the building is supplied

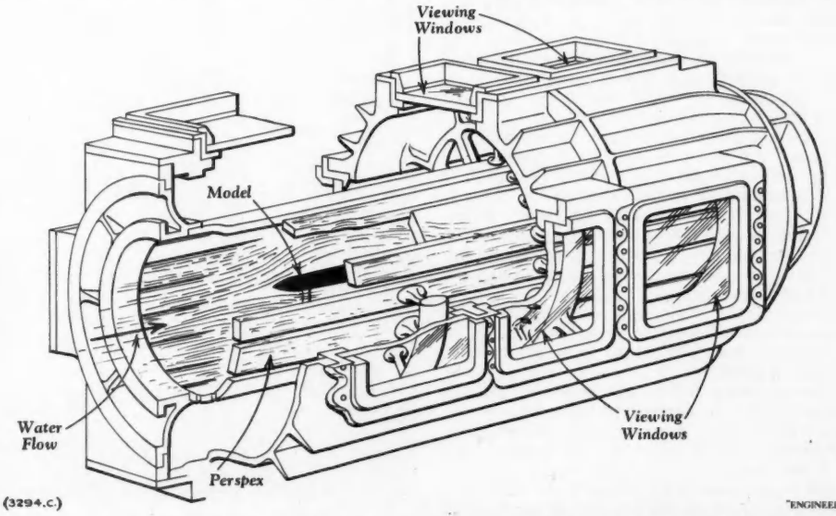


Fig. 3 The working section of the 30 in. water tunnel is fitted with longitudinally slotted walls which make possible the testing of models up to 10 in. in diameter and 10 ft. long.

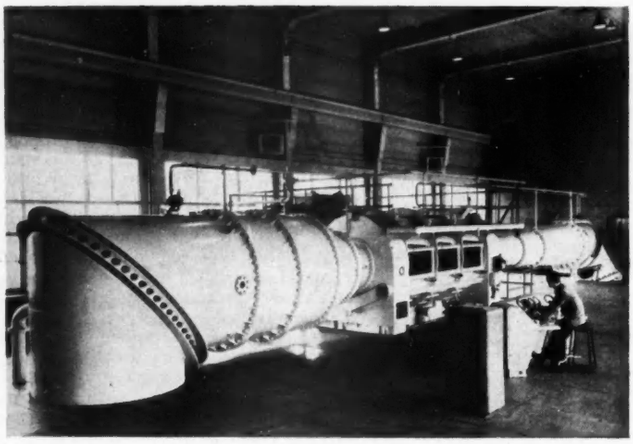


Fig. 4 Speeds up to 35 knots and pressures variable from 2 to 45 lb. per square inch absolute are provided in the 30 in. water tunnel.

by a plenum plant located in a chamber suspended from the crown of the dome. Cleaned and heated air is directed radially outwards and downwards over the internal dome surface, and is extracted by fans around the periphery wall.

The intensity of the natural lighting is kept low to discourage the growth of algae. The artificial lighting is concentrated downwards mainly on the water channel, and is provided by specially-designed reflector fittings mounted around the base of the dome and housing 300 watt tungsten lamps. Underwater lighting is used additionally in the observation area.

WATER TUNNELS : SLOTTED WORKING SECTION

Research problems on the behaviour and characteristics of bodies travelling underwater are very similar to those which arise in the aeronautical research for aircraft design. In the aeronautical world an essential tool for this is the wind tunnel, and an exact analogue in the hydrodynamic field is the water tunnel, which consists of water in a closed circuit capable of being pumped at various speeds past models fixed in the working section.

The first major piece of experimental equipment built in the Admiralty Research Laboratory for hydrodynamic research was a water tunnel having a 12 in. diameter working section which was erected in a conversion of an existing building on the site of Upper Lodge, Bushey Park. Its first runs were made in August, 1951.

This 12 in. tunnel is very versatile and can be fitted with a variety of working sections including the conventional closed jet and an open jet section, and was used for all the original development on the new slotted wall working section (see below). The water speed through the tunnel can be varied up to 49 knots, and it has a similar range of pressure control to that of the larger tunnel. In both tunnels, refrigeration plant is needed since at full power the tunnel water temperature would rise unduly without some control by cooling.

The larger of the two water tunnels, which has many unique features, has a jet diameter of 30 in. and is installed in a block 114 ft. long, 51 ft. wide and 48 ft. high sited at the east end of the new buildings. This new water tunnel is capable of testing powered models up to 10 in. in diameter and powered with some 100 h.p. The models are fitted internally with all the necessary measuring instruments. The speed in the working section of the tunnel is continuously variable up to 35 knots and the pressure at the model can be varied from about 2 lb. per sq. in. to about 45 lb. per sq. in. absolute.

The accommodation of powered models which might be as large as 10 in. in diameter, in a jet which is only 30 in. in diameter imposed a considerable problem, as in the conventional working section of this size the biggest diameter model would have been about 5 in. This problem was solved by the concept of the slotted-wall working section which is partially open and partially closed. The working section takes the form of a cage of longitudinal Perspex bars enclosing the jet of water within an observation chamber, the outer casing diameter being about 2½ times that of the jet diameter (Fig. 3). As a result of this development it has been found possible to double the effective size of the working section, thus permitting the testing of powered models some 10 in. in diameter and up to 10 ft. long; the pressure distribution is substantially constant along the working section and blockage corrections are kept to a low level.

THE 30 IN. TUNNEL CIRCUIT

The main electrical plant, together with ancillary plant for controlling the temperature, air content and optical clarity of the water for the 30in. tunnel, is housed at ground level. The working section is on the first floor.

To allow for the provision of cranes for heavy plant erection, and for carrying out the plant installation under cover, the shell of the building was initially built without the intermediate floor. Thus the building is constructed of heavy steel-frame portals with brick walls, a removable reinforced-concrete panelled first floor and a steel-deck roof system. Brick external walls, acoustic board and fibreboard lined ceilings, and double ground floor windows, are used to reduce reverberation and the transmittance of sound from the plant room.

The tunnel consists basically of a closed circuit of roughly rectangular form, built up of sections of large-diameter high-pressure pipe, standing vertically within the envelope of the building. The upper limb on the first floor contains the test or working section in which the models are placed for test and observation. This working section is contained in a cylinder approximately 6 ft. in diameter and 18 ft. long. It has several toughened glass observation windows, and equipment for supporting and manipulating the test models. The essential tunnel controls are built into a desk adjacent to the working section, and intercommunication is provided between this desk and the plant room.

Into the lower limb of the tunnel is built the pump which circulates the water round the tunnel circuit. It is of the vertical axial-flow type with variable-pitch impeller blades, and is driven by an 850 h.p. 450 volt direct-current motor, with a speed range from 220 r.p.m. down to 35 r.p.m. fed from a Ward-Leonard set. The speed of the pump, and hence the velocity of the water flow in the working section, is electronically controlled to within $\pm$ 0·1 per cent. of the maximum speed in a similar way to the rotating beam drive.

It is essential in experiments of this kind to keep the test-water as bubble-free as possible, and for this purpose the tunnel is fitted with a "resorber" to re-absorb any bubbles that are formed in the water during the course of the experiments. This involves the water in four vertical passes through 11 ft. diameter pipe in a shaft some 65 ft. deep. The last pass continues upwards to form one of the vertical limbs of the tunnel.

EXPLORING THE WATER ENTRY OF MISSILES

Many underwater weapons start their run in air and then have to enter the water at speed and continue their trajectory under water. To help in the study of the water-entry phase a new model water-entry tank 29 ft. long and 9 ft. deep by 5 ft. wide, made up of toughened glass panels, has recently been erected among the new facilities (Fig. 5.)

This tank has been designed to examine the behaviour of 2 in. diameter models which are fired from a slotted-cylinder catapult. This is in many ways similar to a miniature version of the steam catapult used to launch aircraft on carriers and has been developed by the same designer. The catapult is fired by compressed air and can project the models into the tank at speeds up to 180 knots, corresponding to about 570 knots full scale. The catapult is mounted at one end of the tank and can be adjusted to fire the models at any angle of entry between horizontal and vertical.

The slotted-cylinder catapult is used so that the models can be pitched and yawed on the carriage to simulate the conditions of off-trajectory shots which occur under full-scale conditions. The glass-sided tank is fitted with special lighting facilities which give high intensity illumination and permit high-speed photography of the moving bodies.

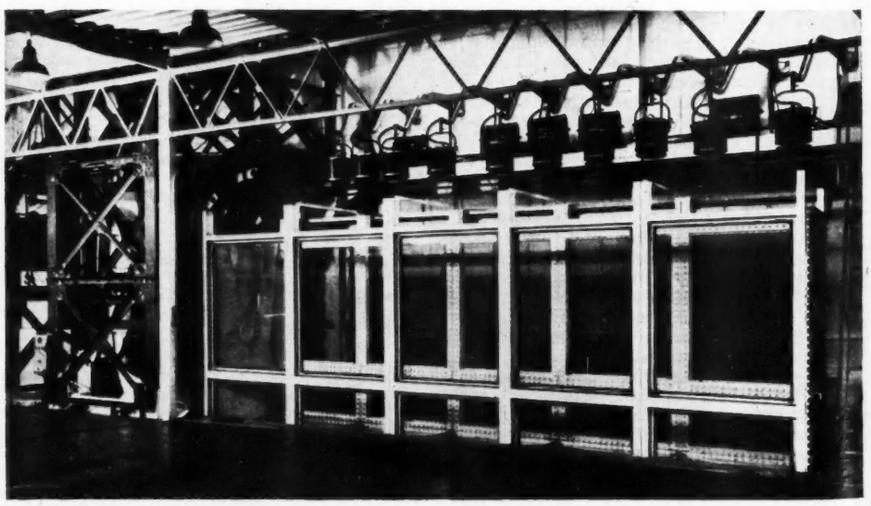
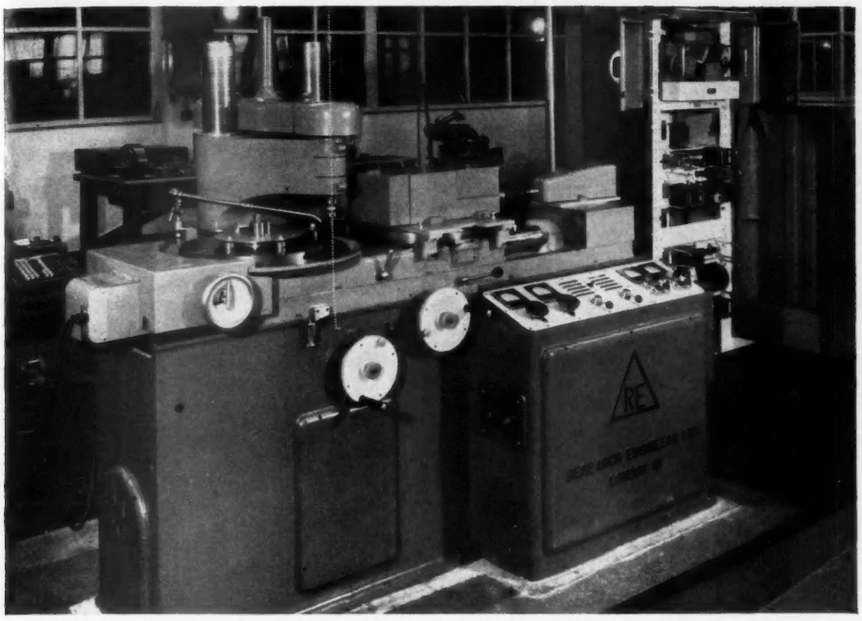


Fig. 5 Water-entry tank for investigating the entry of air or surface-fired model missiles into the water. The compressed-air missile-launching catapult is carried on the structure at the left.



The electronic control unit on the right accepts data from a perforated tape and operates the servo-unit which replaces the master cam. This unit is shown mounted above the right-hand work-table, ready to be moved forward so that its plunger will contact the copy follower.

PROFILE MILLER WITH ELECTRONIC PROGRAMME CONTROL

CAMS CUT DIRECTLY FROM POLAR CO-ORDINATES

Although several machines equipped with electronic programme control have been constructed and described, the profile miller recently installed at Laurence, Scott and Electromotors Limited, Norwich, is believed to be the first, either in this country or America, to be used for regular production work. The electronic programme equipment for it has been designed and constructed by Electric and Musical Industries Limited, Hayes, Middlesex. The system employed can be used with any machine tool.

The machine itself is a profile copy miller made by Research Engineers Limited, Northampton-grove, London, N.1, and is shown in its modified form in the illustration. It is a vertical-spindle machine of extreme accuracy, designed to work from a hand-made master. It uses a sensitive servo-mechanism operated by a follower, and this has been incorporated in the electronic control. In the conversion, the master has been replaced by a simulator, driven from a servo-motor and mounted over the master worktable, which causes the copying stylus to move in and out in response to signals from the controller. Greater accuracy is achieved by the electronic system, and the expense and time involved in making a master are eliminated.

OPTICAL CONTROL SYSTEM

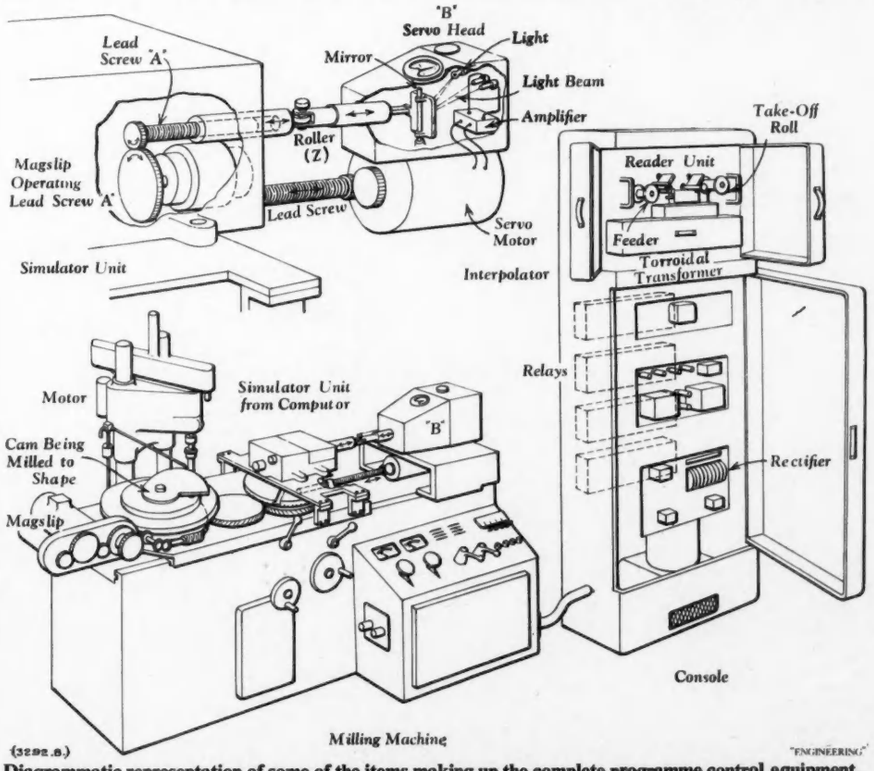
The general arrangement of the machine can be seen in the illustration. The two work tables are geared together and are rotated by a single motor. The cam to be cut is placed on the left-hand table and the master on the right; in the illustration the servo-mechanism which replaces the master is shown in position. On the right of the machine is the follower which in the standard machine traces the master and in the adapted model moves in response to the controlling plunger.

In this machine, the milling head has only a vertical movement and the work tables move horizontally under the control of the machine's integral servo-system. The carriage bearing the work tables slides on an intermediate bed which itself can be moved by a handwheel. Movement of the intermediate bed affects the depth of cut being taken without altering the relative positions of the master and the follower. There are both hand and power feeds for most of the movements, and there is a correcting circuit which is arranged to adjust the speed of rotation according to the slope of the cam being cut, so that a constant cutting rate is maintained. Power is supplied by a double Ward Leonard set built into the base of the machine, one section of which supplies the cutter motor and the other, the worktable motor. The field of the generator supplying the table motor is controlled partly by a hand rheostat and partly by the electronic unit regulating the cutting speed.

The integral servo control, which is directly operated by the follower, is primarily an optical system. A mirror attached to the follower arm deflects a beam of light to either one of two photo-cells according to the follower movement. The signals from these cells are amplified and used to operate a servo-motor driving the lead screw of the table carriage. A follower movement of 0·0001 in. is sufficient to energise the circuit. A centre-zero meter mounted on the unit shows follower deflections in graduations of approximately 0·0001 in. Table movements can be read on another optical head with an accuracy of about $\pm$ 0·0005 in. The work tables are 18 in. in diameter and will take work of 12 in. radius. The carriage has a traverse of 13 in. Some details of the various units are shown in the diagram below.

SIX WEEKS REDUCED TO TWO HOURS

In the particular operation shown, the machine is cutting a cam of fairly large size. Normally the procedure would be that the design department would supply a series of polar co-ordinates determining the profile of the cam, and these would be interpolated so that the final shape could be exactly checked. The master cam would then be roughly machined and finished to size by hand, the total time involved from the receipt of the co-ordinates to the completion of the master being, perhaps, six weeks. With the electronic system, the initial co-ordinates are transferred to a perforated tape by a typist working a modified tele-typewriter. The tape is then fed through a reading head and translated by the control unit to the plunger servo and thence to the machine, the overall time being reduced to



Diagrammatic representation of some of the items making up the complete programme control equipment. A correcting circuit adjusts the rotational speeds of the worktables to maintain a constant cutting rate.

about 2 hours only, of which ½ hour is cutting time. With this particular machine, since the work tables rotate, polar co-ordinates can be used directly. It is equally possible to use Cartesian co-ordinates for other machines, with servo-motors driving the lead screws directly. The perforated tape working on the binary system was chosen for its simplicity.

Celluloid tape was employed in the first model as it was thought that the extra strength would be needed. This has not proved to be the case, however, and paper tape has proved quite satisfactory. The change has enabled a punch machine of the standard type to be employed, with consequent saving of initial cost.

Errors made in typing (figures are printed simultaneously with holes) can be erased and are ignored by the reader, which scans the tape with feelers, and transfers the information to a store through a series of telephone relays. Voltages are produced from tapped transformers adjusted in proportion to the holes in the tape; three sets of information are held in the store at once. Since it is important that the finished profile should be a smooth curve, the three sets of information, representing three adjacent co-ordinates, are summed and a parabola is fitted to them by an interpolating circuit. In this, two tapped transformers supply the linear and quadratic terms of the equation; there are 64 steps of interpolation on the linear transformer and 10 on the quadratic. The latter consists of a tapped mains transformer, the tappings to which are themselves fed through secondary transformers to give the correct voltages. In both cases a servo-driven switch scans the interpolations and these are compared with the voltage from the position indicator attached to the plunger, the servo driving the latter moving to keep the voltages in balance. As the co-ordinates are normally given every 1 or 2 deg., a very smooth curve results; indeed during experiments it was necessary to increase the interval between co-ordinates to 36 deg. before the steps due to the interpolations became visible above the ordinary milling marks.

Movement in or out of the plunger is detected by the follower and relayed to the machine's integral servo-system. This operates so that the follower always tends to remain in one spot—that is if the plunger moves outwards (and therefore pushes the follower inwards) the servo motors move the table to counteract this movement. The tape is fed through the reading head in synchronism with the rotation of the work-tables, of which the master is marked in degrees and has a positional pointer to mark the starting place. The speed of cutting is limited by the design of the machine only; controls allow variation in table rotation speeds from one revolution in 6 minutes to one in 60. The machine stops automatically after one revolution.

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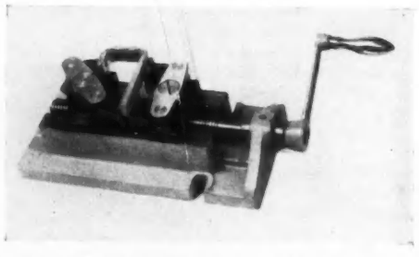
VICE TO HOLD IRREGULAR SHAPES

A machine vice designed to hold parts of non-uniform section or irregular shape is marketed by Headland Engineering Developments, Limited, 164–168, Westminster Bridge-road, London, S.E.1. The "Polyp" variable-angle machine vice is shown in the illustration below; it has a cast base, and both jaws are driven along dovetail-section guide ways by a square-thread screw which is relieved at its midpoint to accommodate left and right-hand thread forms.



Each jaw of this machine vice consists of a bridge piece and two grip-links. The four grip-links can be arranged to hold almost any part presenting four surfaces for clamping.

Each jaw consists of a steel block with a bridge-link and two grip-links. Each of the four grip-links can be swung through a wide angle in the horizontal plane, while the bridge-link in each assembly can be rotated through 360 deg. By selecting the appropriate jaw-angle combinations almost any part presenting four surfaces for clamping can be held. It is not necessary to align the jaws precisely prior to holding a part as the linkages are self-adjusting.

When the jaws are set for parallel operation, the vice can hold work up to 5½ in. in thickness. In this setting the width across the jaws is 4 or 5 in. depending on the rotation of the linkage.

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JAMES WATT'S WORKSHOP

Replica at Science Museum

The contents of James Watt's workshop are on public view again in the Science Museum, South Kensington, London, S.W.7. They are displayed in their correct positions in a replica of the workshop incorporating the old door, window and floor-boards and include Watt's two sculpture-copying machines and lathe, all treadle-driven; many small tools, plaster busts and casts; his old leather apron and some school books of his younger son, Gregory Watt.

The garret workshop was on the second floor at Heathfield, the house near Birmingham built by Watt in 1790, where he lived till his death in 1819. He used the workshop during his retirement from 1800 onwards for many experiments but not for the development of the steam engine, which he did 25 years previously in Boulton's factory at Soho.

The contents of the workshop, which had lain practically undisturbed for a hundred years, were presented to the nation by Major J. M. Gibson Watt when Heathfield was demolished in 1924. An illustrated pamphlet, written by Dr. H. W. Dickinson, and published by H.M. Stationery Office, price 9*d.*, is available.

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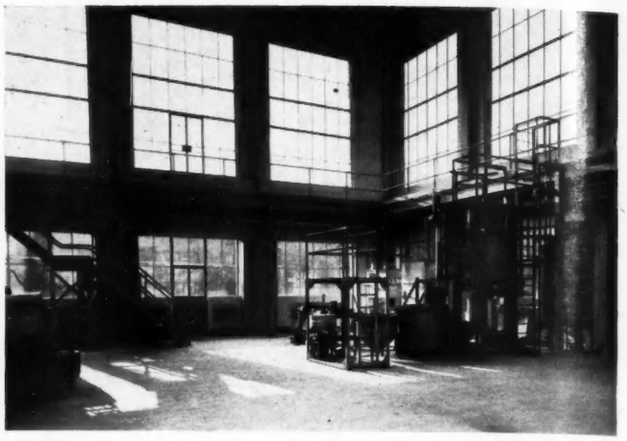
WHEELED CROWBARS

Crowbars with wheels fixed at the fulcrum point are very useful for moving heavy loads. They give a lift of several inches, sufficient to enable a sling to be passed underneath, and are not so liable to damage the floor. By using two or more simultaneously it is possible to move loads in confined spaces and over fairly long distances. Two sizes are being made by Richard C.. Gibbins and Company, Limited, 1A Fenchurch-street, London, E.C.3, one 4 ft. long for loads up to 3 tons, and one of 5 ft. for loads of 5 tons.

The largest of three new laboratories built for the Gas Council London Research Station is designed to house large pilot plants; it has a floor area of 3,000 sq. ft. Sampling and biological treatment are the main concern of the other two.



GAS RESEARCH

Laboratories Extended at Fulham

Although the production of fuel gas from coal and other sources is a practice of long standing, there is still much to be learnt, and improved methods remain to be tried. In 1924 the Gas Light and Coke Company set up their first laboratories at Fulham for research into the processes. New buildings were erected in 1928, and in 1948 these were extended. After nationalisation, the premises were designated the London Research Station and became one of the two main stations in the country. With the steady increase in the work, the old buildings became somewhat cramped, and a new building, containing three laboratories, was officially opened on November 18 by Sir Robert Robinson, O.M., F.R.S. These bring the total number of laboratories at Fulham up to seven.

The largest of the new laboratories—No. 5—is illustrated above. It has a floor area of 3,000 sq. ft. and is designed to accommodate big pilot plants. For this purpose it is equipped with a 2 ton overhead crane. In the foreground can be seen equipment used in the manufacture of a catalyst for removing organic sulphur from gas—a process which is being studied in one laboratory in the old building and is becoming of increasing importance. The experimental method now under investigation gives a removal of 97 per cent., and leaves the sulphur in a recoverable form. The apparatus in the background of the illustration is concerned with the life of refractory materials, particularly in regard to damage by scurf.

BIOLOGICAL PURIFICATION

The treatment of effluents is a problem which faces many factories. Gasworks suffer badly in this way as the liquid effluents from them contain phenolic substances and thiocyanates which render them poisonous to both plant and animal life. In one of the new laboratories, the treatment of these effluents by micro-organisms is being tried. Strains have been cultivated, from types living in soil, which can live in phenol and thiocyanates and will break down these compounds, rendering them harmless. A subsequent process for bleaching the liquor is being developed. In the third laboratory, the work now in progress is the development of sampling techniques and automatic apparatus for the testing and analysis of the performance of gas-making plant. All new or reconstructed plant of the North Thames Gas Board is subjected to these tests by a mobile team.

With the passage of time, the emphasis of research has shifted from the investigation of the efficiency and characteristics of established processes to the development of new methods and of novel chemical processes. In particular, the use of sources other than coal is coming to the fore, and most of the new plant to be installed will use oil as the raw material. Waste from oil refineries, and liquified methane from abroad are other sources of fuel gas now being examined.

CORELESS INDUCTION FURNACES

MAINS-FREQUENCY SETS FOR MELTING SCRAP AND SWARF

The principle of the coreless induction furnace has been known for many years, and several attempts have been made at different times to build a unit that would operate at mains frequency (50 cycles). In the post-war period research has been undertaken by Otto Junker G.m.b.H., of Lammersdorf, Germany, the Ajax Engineering Corporation of Trenton, New Jersey, U.S.A., and Birlec, Limited, Tyburn-road, Erdington, Birmingham, 24. An arrangement has recently been reached between these three companies, and in connection with this, meetings have been held in this country to introduce this type of furnace to potential users. The subject has been introduced by Mr. F. S. Leigh, of Birlec's, and Dr. K. Scherzer, of Junkers. The former dealt with the theoretical side and the latter with practical applications of which Junkers have had considerable experience.

In the coreless induction furnace, a typical example of which is shown in Fig. 2, the charge forms the secondary coil of a transformer of which the primary is fed from an alternating current supply. As there is no iron circuit (core), the transformer efficiency is reduced; this can be compensated by working at a high frequency (and there are many furnaces using this method) or by using an intense magnetic field. The latter is employed with mains-frequency furnaces, which have the advantage over the high-frequency type that no frequency conversion apparatus is required—apparatus which is often very expensive. Thus, for the same performance, the total cost of a mains-frequency furnace, including control equipment, is only one-half to two-thirds that of a complete high-frequency plant. The electrical efficiency of a 50 cycle furnace of 15 cwt. capacity is probably about 5 per cent. less than one working at 500 cycles or over, but the losses involved in the frequency-conversion equipment more than offset this, so that overall the 50 cycle plant is probably about 10 per cent. more efficient. The power factor is probably twice as good, which will allow a considerable reduction in the condenser capacity required. As with all types of induction furnace, the diameter of the charge is governed by the depth of current penetration. Experience so far accumulated has shown that the minimum capacity for efficient operation under normal conditions is 15 cwt.

With the higher currents of the 50 cycle furnace, the stirring effect on the charge is greater and can be governed by dividing the primary coil or by the use of a tapped transformer in the primary supply. As the coils are subjected to very high mechanical forces at this frequency, they have to be robustly built; in general a single-phase coil is preferable, as furnaces which have a crucible (as is used in the melting of magnesium) show considerable distortion of the latter after a little use when working on a three-phase system. To provide a single phase load from a three phase supply, two different circuits have been worked out; these are shown in Fig. 3. Circuit *A* is slightly more expensive as sufficient capacitors must be provided to ensure unity power factor for the furnace circuit, but circuit *B* has the drawback that the maximum power factor that can be achieved without using a supplementary three-phase capacitor is 0·866. Circuit *B* will also only give perfect balance at one particular furnace load, whereas *A* can be adjusted to give a balance at any furnace input.

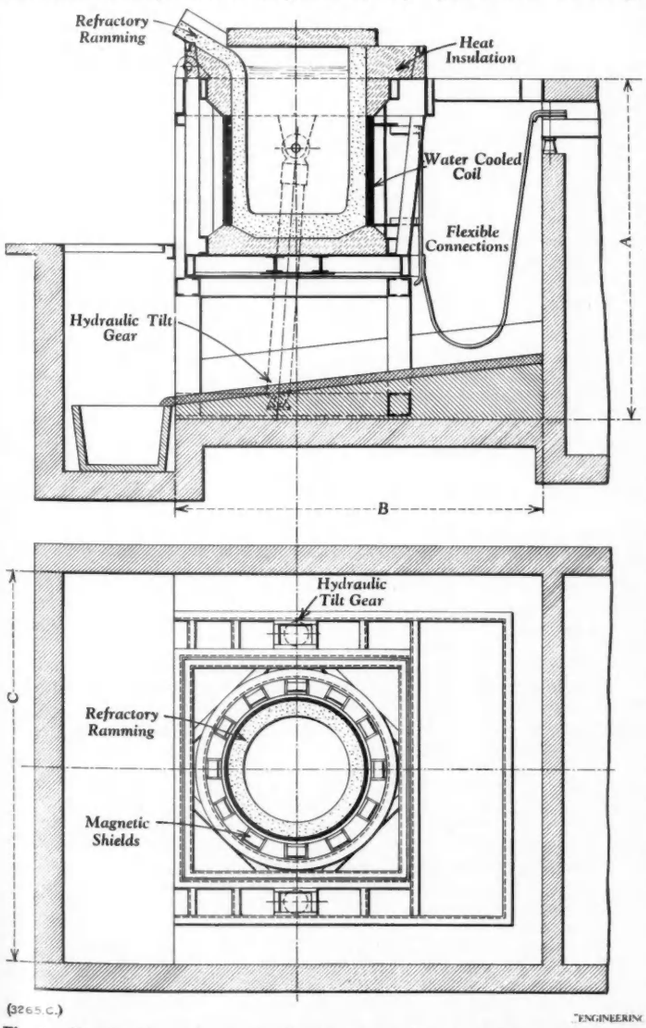


Fig. 1 Construction of a mains-frequency coreless induction furnace. It is particularly suitable for producing a melt of exact composition from scrap, swarf or borings.

FURNACE CONSTRUCTION

The construction of a typical low-frequency coreless furnace is shown diagrammatically in Fig. 1. The furnace body is designed on similar lines to those of high-frequency units of medium or large capacity. The framework is of structural steel and is protected from stray magnetic fields by a shield. The coil is wound from extruded copper of hollow section, through which cooling water flows. The insulation is glass tape covered with silicone varnish, impregnated and stove dried. With its magnetic shields, the coil is mounted between two collars made from rolled steel sections to form a single unit. Tilting is usually carried out hydraulically, using two rams, as indicated in the diagram. Lip axis tilting is standard practice. It is usual to fit a cover to the furnace crucible to reduce radiation losses as far as possible during operation; such covers are generally moved by hand.

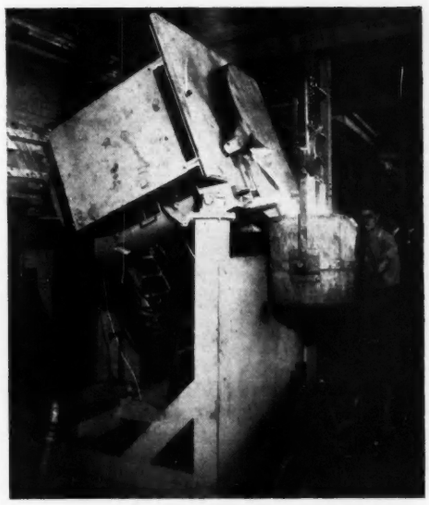


Fig. 2 A coreless induction furnace rated at 250 kW and with a capacity of 18 cwt. of iron. By using alternating current at mains frequency, the expense of conversion equipment is avoided.

For most applications, the crucible is formed of rammed refractory material, which has a long life and can be chosen to suit the alloy being melted. Hair cracks in the refractory give rise to very little trouble as they become filled with metal, which cools as it moves outwards and solidifies, forming a seal and preventing failure. In this way a good furnace life can be expected, probably slightly better than that of a corresponding high-frequency plant. As indicated above, for melting magnesium it is customary to use an iron or steel crucible in place of the refractory lining, in which case the magnesium is heated by conduction from the crucible wall; the thickness of the wall governs the amount of stirring that is imparted to the charge. The smooth interior of the furnace permits easier cleaning than can be carried out with the channel type, and the absence of the channel also removes any risk of choking. As compared with the hot-blast cupola furnace, there is no danger in an induction furnace of contamination by sulphur.

Possibly the biggest single advantage of these furnaces is their ability to handle a charge consisting solely of chips, swarf or borings, although it is usual to add these to a "heel" of metal, either solid or already molten, resulting from an earlier melt. The circulation induced by the current stirs the chips into the heel and so melts them quite rapidly. Higher temperatures can be attained than with either the channel or cupola type although the rate of melting is lower than when a high-frequency supply is used. Superheating at 1,400 to 1,500 deg. C. can be successfully carried out with very little loss of carbon or silicon. Alloying can be effected in an induction furnace, but this is not considered economical. It is recommended that such work should be done in a holding furnace and that mains-frequency induction furnaces should be used for melting only. Since scrap of known composition can be used as the charge

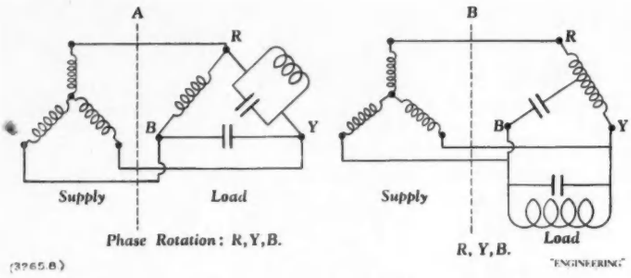


Fig. 3 Alternative methods of balancing a single-phase load from a three-phase supply. "A" is more flexible but also more expensive initially. The two circuits have both been considered for coreless induction furnaces.

and the losses of constituents during melting are extremely small, the product of one of these furnaces can be kept to a very exact composition. The intense stirring does not allow segregation of any constituent to occur. Furnaces ranging in size from 15 cwt. to 8 tons are now in use for melting iron, high-alloy steel, aluminium and light alloys, magnesium, and brasses and bronzes. For melting cast iron, an electricity consumption of about 500 kWh per ton is the average, and superheating requires about 50 kWh per ton per 100 deg.

PHILOSOPHY OF AIRCRAFT DESIGN

A PROCESS OF STRUCTURAL REFINEMENT

Assessing the flight loads on an aircraft and assigning safety factors, designing an aeroplane structure that can withstand a fatigue crack without disaster, and methods for proving the structure under static, repeated and thermal stresses, were subjects under discussion recently by members of the Royal Aeronautical Society at an all-day session in London on "Aircraft Design Philosophy."

FLIGHT LOADS

The opening speaker was Mr. R. H. Sandifer, of Handley Page, Limited, who discussed "Flight Loads" from the viewpoint of the official civil and military requirements, and the possible revisions that might be needed. The prescribed "flight envelope" was, he said, a graph of the specified normal acceleration factors plotted against speed, within the boundaries of which the aircraft might be safely manoeuvred. In stressing the aircraft, overall safety factors were imposed on the maximum expected loads defined by the envelope. Generally the pilot was not provided with an acceleration recorder, but relied on training and experience to control acceleration. Possibilities of a "*g*-restrictor" to limit normal acceleration had been considered, but the advantages were debatable.

Vertical gusts produced additional loads proportional to the product of gust speed and flight speed. The civil requirements specified that the aircraft should withstand a 66 ft. per second gust at the design speed for maximum gust intensity, a 50 ft. per second gust at maximum continuous speed and a 25 ft. per second gust at maximum diving speed. This was based on the idea that an aircraft approaching turbulence was more likely to meet a low-velocity gust on the fringe of the area, and the pilot could then reduce speed before encountering severer gusts. Gust intensities and frequencies were generally less at altitude, but Mach number effects might cancel these reductions; there was need for more gust research above 30,000 ft. The effect of gust gradient was important, and on large fast aircraft it was desirable to carry out full dynamic response calculations, taking into account the elastic characteristics of the wing structure, for a range of gust gradients.

Turning to rolling and yawing loads, Mr. Sandifer said that in spite of the safety factors normally applied, it had been found that high-speed aerobatic aircraft could be fairly easily manoeuvred to higher accelerations. Again it was desirable to carry out response calculations whenever data were available; more research was required in this field.

After touching on the safety aspects of automatic pilot design, on control surface loads, and on pressure cabins, Mr. Sandifer concluded with a brief survey of the future. Legislation restricting speed and acceleration would be required to control temperature gradients within the structure, and time limitations at a given speed might be necessary because of the creep characteristics of available structural materials. Artificial cooling and insulation might have to be specified, and the provision of accelerometers and some positive form of speed control would be essential.

Wing and control surface characteristics designed for optimum performance at high Mach numbers might have different low speed characteristics, and requirements now governed by stalling speed might in future be governed by buffeting or other phenomena. Jet flaps might give rise to increased wing torsion and overall wing twist, and would call for new design criteria for controls.

Methods of estimating structural distortions were already under revision because of the complex nature of modern wing structures and new plan forms; and the present aeroelastic requirements were in need of restatement since they had little meaning when applied to a delta wing. Notwithstanding the use of new temperature-resistant materials, overall thermal distortions of wings and tail surfaces might occur and increased aeroelastic changes might accompany wings designed for supersonic speeds. These factors would have to be included in response calculations for manoeuvre loading.

The general impression arising out of the discussion which followed Mr. Sandifer's paper was that the manoeuvring strength requirements needed revision—that some of the yaw manoeuvres specified for military aircraft were unrealistic and unnecessary, whereas requirements for certain rolling manoeuvres were inadequate. One speaker felt that the requirement for civil aircraft to withstand 1*g* negative accelerations was superfluous, but it was pointed out that airliners had been known to indulge in inverted flight and that passengers must be safeguarded. It was felt by several speakers that, since selection and training of Royal Air Force pilots was now extremely rigorous, there was less need for allowing margins for faulty piloting technique, and requirements should be based only on essential operational manoeuvres.

SAFETY FACTORS

Closely linked with the consideration of flight loads are "Safety Factors," introduced into the discussion by Mr. J. K. Williams of the Air Registration Board. Two types of loading condition could affect the aircraft structure—the "limit loads" which occurred very rarely during the lifetime of the aircraft, and the loads which occurred repeatedly such as gusts of low magnitude which were fairly frequently encountered, or high loads such as those acting on the pressure cabin acting perhaps 10,000 to 20,000 times in the aircraft life.

Associated with the limit loads were two design factors. The proof factor (ratio of design proof load to design limit load), was intended to ensure that after application of the limit load the structure would be free from serious deformation. This factor was specified as 1·0 for civil aircraft and 1·125 for military aircraft, probably because the latter more frequently reached and exceeded the limit load. The ultimate factor, or factor of safety, was the ratio of design ultimate strength to design limit load—generally specified as 1·5—and was intended to ensure against strength variations in the structure. Associated with the repeated loads was a fatigue factor of safety to take into account loading and fatigue strength variations.

In the past, structural safety had depended on the pilot's operating technique based on experience, weather information and knowledge of the recommended safe speeds for the aircraft. The present gust standards had been introduced 10 years ago, and much had been learnt since then; gusts up to 72 ft. per second had been encountered in the United States Thunderstorm project in 1947; civil acceleration records had shown that the limit gust load was exceeded about once in every 2,500 flying hours—a relatively high frequency. In spite of this, the unserviceability rate during the last 10 years had not been unduly high.

Static and fatigue loading should be considered as separate design cases, and the use of a static safety factor alone did not necessarily cover fatigue. A fatigue life factor of the order of 6 was used when specifying retirement lives for structural components on British civil aircraft, applied to the calculated life of an average component operated in average load conditions.

Mr. Williams then turned to the "fail-safe" structure—i.e., an airframe which could continue its flight without catastrophe after the initiation of a fatigue crack—and said that it would be necessary to demonstrate not only that a wing, for example, could withstand the sudden failure of a major structural member, but also that after such a failure it could continue to withstand the factored limit load.

An acceptable level of structural safety had been achieved in the last 10 years for piston-engined civil aeroplanes of conventional configuration designed to common airworthiness loading standards and aerodynamic loading assumptions, and proved by standard strength tests. For the new generation of heavier high-speed high-altitude aircraft now arising, fatigue loading assumed an even greater importance, for the fuselage as well as for the wing structure. Changed operating techniques, by eliminating hidden strength margins, vested greater responsibility in the pilot to avoid structural damage, by controlling speed and altitude when given warning of turbulent conditions. Powered controls might give unduly light control-feel characteristics, which could adversely affect aircraft safety in turbulence. Increased wing flexibility and Mach number effects would affect the limit design criteria.

During the discussion following Mr. Williams' paper, it was pointed out that, although he had quoted a figure of 6 to be used as a safety factor on the measured fatigue life of components, the printed official requirement still quoted static factors of 1·5, 2 or 3, ostensibly to cover fatigue requirements. These factors, it was suggested, were meaningless and should be replaced by life factors. In opposition to this was the opinion that a safety factor specified on fatigue stress rather than on life was preferable because a slight change in stress could produce a large change in life. Another speaker put forward the view that the concept of safety factors—or factors of ignorance—was a wrong philosophy, and that more conservative design assumptions should be made in the first place, allowing larger adverse tolerances for the material.

FATIGUE AND "FAIL SAFE"

"The Design Philosophy of Aircraft Fatigue" was introduced by Mr. H. Giddings of the Bristol Aeroplane Company, Limited. Because of the difficulties of determining the load/cycle variations on an aircraft and because of the wide scatter of fatigue test results, many aircraft engineers believed that complete freedom from fatigue failure during the life of an aircraft could not be obtained without an unacceptable weight penalty. This led to the concept that, should a fatigue crack occur in operation, it must develop slowly and not lead to unacceptable loss of strength before inspection and repair was possible: the failure must be "safe." Inspection periods must then be based on this assumption, and good access must be provided so that cracks, dents, scratches, etc., could be readily detected.

To support his view that no primary airframe component could be excluded from fatigue considerations, Mr. Giddings demonstrated that, if the Britannia undercarriage had been designed solely on static strength criteria, it would be subjected to loads amounting to about 40 per cent. of the static ultimate strength once every landing—i.e., about 10^4 repetitions of this load in its lifetime of, say, 10 years. Similarly, hydraulic jacks and components, if designed to static strength criteria, would undergo at least 10^4 repetitions of load amounting to 50 per cent. of the static ultimate strength. Additional stresses would be imposed by ground manoeuvres or by hydraulic pressure fluctuation.

The large scatter range of fatigue test results made the determination of realistic safety factors a difficult statistical problem, and was a serious point of criticism against full-scale fatigue testing such as the "tank" test, the cost of which permitted only one specimen to be tested. It was easy to specify a large factor of safety, between 5 and 10, but not so easy to sell the aeroplane which resulted from these large factors.

Current trends in fatigue testing were to follow a programme of varied loading cycles instead of carrying out separate tests at constant amplitude. There was some evidence that this reduced scatter. In detail fatigue testing, a pre-load of $2g$ was applied before the fatigue test to reduce scatter.

Another unsatisfactory factor in fatigue testing was that fatigue test machines were usually run relatively fast, in comparison with the actual frequency of loading on an aircraft, so that the corrosive effect of the environment—air, sea water, hydraulic oil, or condensation—which was time-dependent, was not represented.

Returning to the "fail-safe" concept, Mr. Giddings said that one of the first steps in applying the principle was to study rate of crack growth and to establish the factors which govern this rate. Much work had already been done by the Bristol Company, who had also investigated the effect of crack "stoppers"—flat reinforcing strips riveted or bonded to the test specimen. The strips, particularly those Redux-bonded, were effective in arresting cracks. Another approach to "fail-safe" design was to provide alternative structural load paths. The United States National Advisory Committee for Aeronautics were doing experiments on this. In all this work neither the problems nor the solutions were yet fully understood.

In conclusion, Mr. Giddings summarised his "philosophy of design" for fatigue: analytical loading study for all primary components; careful consideration of choice of material in relation to the stress level (the low and medium-strength aluminium alloys having better crack propagation properties than the high-strength alloys); detail design to minimise stress concentrations, by the use of metal adhesives, integral stiffeners, close-tolerance riveting, pre-tensioning of both by controlled torque loading, interference fits for bolts in shear, etc.; design to ensure low rates of crack propagation; extensive fatigue tests of components; flight strain-gauge tests to confirm loading data and to show up areas of stress concentration; the operational use of counting accelerometers and strain gauges to facilitate the selection of optimum operating conditions; and a high standard of maintenance and inspection to ensure minimum ground handling damage and detection of flight damage. On this basis, he thought, a safe long-life aeroplane could be achieved without a significant weight or economic penalty.

In the discussion following Mr. Giddings' paper, some speakers put forward a view contrary to that expressed in the earlier discussion on Mr. Sandifer's paper—that pilot errors should receive more consideration from designers; and that as speeds, altitudes and ranges increased, responsibility must be taken away from the pilot and handed over to automatic devices. It was agreed that much more would need to be learnt about their failure rates.

In further discussion on the "fail-safe" philosophy, it was learnt that work at the Royal Aircraft Establishment indicates that a "fail-safe" structure could be achieved without any weight penalty, by re-distribution of the material. Advocates of the philosophy had not yet reached the stage of deciding whether, on detecting a crack in the structure during inspection, it should be patched up—as was the practice in America—or whether the aircraft should be withdrawn from service. In any case, the latter practice would be more economic than the present practice of predicting the life, adding a large safety factor and withdrawing the aircraft from service long before the cracking stage had been reached.

STRUCTURAL TESTS

The last speaker, Dr. P. B. Walker of the Royal Aircraft Establishment, dealt with "Aircraft Structural Strength Testing." Major static strength tests of large portions of the aircraft, such as complete wings with part of the fuselage, were essential to safety. Analysis of test results over the last 17 years showed that about half the structures, as originally designed, failed to reach the required strength standard. Usually, however, they were easily brought up to standard without great weight penalty, and were then more efficient structures on a strength/weight basis. It was clear that, since the proportion of initial failures on test had not declined during the last few years, the advances in knowledge and experience had been directed largely towards weight saving. The philosophy of taking risks in initial design, secure in the knowledge that ultimate safety was ensured by the final test, was now widely accepted.

Most premature static failures were due either to structural instability or stress concentrations. Non-destructive proof tests were unsatisfactory for detecting structural instability, which occurred with little or no warning.

Unexpected local stress concentrations could often be revealed by comprehensive strain-gauging before there was any risk of failure; and fatigue tests were much more effective than static tests for detecting stress concentrations. Static tests would still be necessary for ensuring against structural instability.

The three main causes of fatigue were gusts, cabin pressurising, and manoeuvres. In general, manoeuvring loads merely aggravated the effects of gusts and cabin pressure; but the wings of ground-attack fighters were heavily loaded each time a pull-out was made, and fatigue was a definite hazard.

Since major fatigue tests of complete aircraft or large units were extremely costly, repetition testing to determine safe lives had to be confined to selected critical components. Major fatigue tests were required to discover weak places which might otherwise be unsuspected, and for the study of crack propagation. For such tests to be effective, it was necessary to repair the test airframe after each failure and to continue the test for a long time.

The earlier method of vibrating wings and tail surfaces at their natural period was giving place to direct loading by hydraulic jacks, since for large wings with a low natural frequency excitation was difficult.

In pressure-cabin fatigue-tests, water was generally used as the pressurising medium owing to the explosive damage caused by failure in an air test, which rendered difficult the detection of the origin of the fracture. Since air and ground-manoeuvring loads might reduce the life of the pressure cabin, it was desirable to load wings and fuselage to represent lift and gust cycles.

With the prospect of high supersonic speeds, the mechanical loading system had to be combined with a complex thermal loading system. The requirements of the test heat source were: (*a*) adequate rate of heat generation (about 20 kW per square foot of surface was associated with Mach 4 at 50,000 ft.); (*b*) rapidly controllable output to simulate the complex time-temperature pattern of supersonic flight; and (*c*) separately controllable heats for different parts of the surface.

The quartz infra-red lamp had now been developed to meet all these requirements. A suitable electronic controller had been developed to follow the prescribed thermal pattern in relation to time. Large numbers of lamps were required for an aircraft structure to control the output to different parts separately.

Induction heating, which offered the advantage of a heat-input rate much greater than that from infra-red lamps, was under development for still higher speeds. It was, however, much more difficult to control the variation over the surface of the structure. Also the rate of heat production depended on the electrical and magnetic properties of the structural material, which themselves changed appreciably with temperature.

Among the points raised in the discussion on Dr. Walker's paper was the suggestion that an "engineering" approach to aircraft stressing was required rather than a mathematical approach; that the introduction of thermal loading into structural testing would mean a reversion to a more approximate mechanical loading system, in that it would not be possible to distribute the loading over the surface.

The question of detecting cracks on internal structure was raised, and while it appeared that there was no certain method, radiographic techniques were of some assistance. If the "fail-safe" philosophy were to be adopted, it was suggested, the designer should prepare schedules of where cracks were likely to occur, and how they should be treated.

"Fail-safe" was the dominant theme of the general discussion which followed after an interval; it was agreed generally that the aircraft should be designed with the intention that it should not fail, and that the "fail-safe" characteristics should be regarded not as "the first line of defence" but as "defence in depth." One speaker suggested that the chances were that the measures taken to ensure that cracks would spread non-catastrophically—which implied a low stress level—would in themselves materially increase the fatigue life of the structure.

Earlier, a speaker had suggested that in view of the notch-sensitivity of high-strength alloys and the difficulties of avoiding locked-up stresses arising in their fabrication, it might be preferable to revert to the use of lower-strength alloys. This view was contested by a representative of the metal industries, who said that when properly handled they offered great advantages. It was agreed, however, that the stronger materials were less tolerant of design mistakes.

The suggestion was made that scratches and dents of the type that occur in the service life of the aircraft should be simulated in the aircraft fatigue test. The use of controlled torque adjustment of bolts and interference fits should be used as "defence in depth," and not counted on from the airworthiness aspect, since such devices were subject to damage in service.

Another subject discussed was the use of "*g*-restrictors" to restrain the pilot from putting on an excessive normal acceleration. Generally it seemed to be felt that, while it would eventually become essential to develop some means for allowing the pilot to prevent the rapid build-up of *g*, the use of *g*-restrictors, if not carefully designed, could lead to instability and disaster.

NOTICES OF MEETINGS

Aslib

LONDON
Discussion on "Information Bulletins: Their Contents and Functions." Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Fri., Dec. 9, 6 p.m.*

Association of Supervising Electrical Engineers

LONDON
"Industrial Lighting," by J. G. Holmes. West London Branch. Holophane House, Elverton-street, S.W.1. Tues., Dec. 6, 7.30 p.m.
"Electronics in Industry," by Dr. L. E. C. Hughes. South West London Branch. 32 Worple-road, Wimbledon, S.W.18. Wed., Dec. 7, 8.15 p.m.
Film Evening. North London Branch. 677 Green Lanes, Harringay, N.4. Wed., Dec. 7, 7.45 p.m.
BRISTOL
"Relays and Automatic Control in Industry," by Dr. W. L. Stern. Bristol Branch. Grand Hotel, Bristol. Fri., Dec. 9, 7.30 p.m.
ILFORD
"Commercial and Scientific Timekeeping," by D. Martin. North East London Branch. Angel Hotel, Ilford. Mon., Dec. 5, 8 p.m.
OXFORD
"Automatic Temperature Control," by J. A. Taylor. Oxford and Reading Branch. Electricity Board's Showrooms, 3 Market-place, Reading. Tues., Dec. 6, 7 p.m.

British Institution of Radio Engineers

CARDIFF
Discussion on "The Training of Radio Engineers," opened by Dr. W. J. Thomas. South Wales Section. Llandaff Technical College, Western-avenue, Cardiff. Wed., Dec. 7, 6.30 p.m.
GLASGOW
"Automatic Control of Machine Tools," by H. Ogden. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Thurs., Dec. 8, 7 p.m.
LIVERPOOL
"Radio Meteorology," by K. Davin and F. C. Gibson. Merseyside Section. Chamber of Commerce, 1 Old Hall-street, Liverpool. Wed., Dec. 7, 7 p.m.

Building Centre

LONDON
Film: "Timber for To-morrow." Wed., Dec. 7, 12.45 p.m.

Chadwick Public Lecture

LONDON
"Industrial Dermatitis," by R. M. B. MacKenna. The Wright-Fleming Institute, Norfolk-place, Paddington, W.2. Thurs., Dec. 8, 5 p.m.

Chemical Society

DUNDEE
"Magnetism and the Structure of Inorganic Molecules," by Professor R. S. Nyholm. St. Andrews and Dundee Branch. Chemistry Department, Queen's College, Dundee. Thurs., Dec. 8, 5.15 p.m.
EDINBURGH
"Some Aspects of Research in the Scottish Division of the National Coal Board," by Dr. E. A. C. Chamberlain. Edinburgh Branch. North British Hotel, Edinburgh. Thurs., Dec. 8, 7.30 p.m.

Engineers' Guild

LONDON
Annual General Meeting. Grosvenor Hotel, Buckingham Palace-road, S.W.1. Wed., Dec 7, 5.45 p.m. Preceded by a Metropolitan Branch luncheon at the Mapleton Restaurant, 39 Coventry-street, W.1, at 12.30 p.m.

Illuminating Engineering Society

CARDIFF
"The 1955 Meeting of the International Commission on Illumination," by E. N. Locker. Cardiff Centre. Offices of the South Wales Electricity Board, The Hayes, Cardiff. Thurs., Dec. 8, 5.45 p.m.
NEWCASTLE-UPON-TYNE
"Road Vehicle Lighting," by J. H. Nelson. Newcastle Centre. King's College, Newcastle-upon-Tyne, 1. Wed., Dec. 7, 6.15 p.m.

Incorporated Plant Engineers

LONDON
Discussion on "Incentive Bonuses for Maintenance Workers." Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Tues., Dec. 6, 7 p.m.*
EDINBURGH
"Introduction to Atomic Energy," by J. A. Dixon. Edinburgh Branch. 25 Charlotte-square, Edinburgh. Tues., Dec. 6, 7 p.m.
LEICESTER
Various short papers. Leicester Branch. College of Art and Technology, The Newarkes, Leicester. Wed., Dec. 7, 6.30 p.m.
LIVERPOOL
Film Evening. Merseyside and North Wales Branch. Royal Institution, Colquitt-street, Liverpool. Thurs., Dec. 8, 7.15 p.m.
NEWCASTLE-UPON-TYNE
Film: "A New Approach to Production Development," introduced by S. F. Smith. North East Branch. Roadway House, Oxford-street, Newcastle-upon-Tyne. Thurs., Dec. 8, 7 p.m.

Institute of Fuel

LONDON
Melchett Lecture on "Power, Population and Productivity," by Dr. Alfred Parker. Institution of Civil Engineers, Great George-street, S.W.1. Wed., Dec. 7, 5.30 p.m.*
GLASGOW
"Nuclear Power Generation," by H. A. Davey. Scottish Section. Merchants' Hall, Glasgow. Tues., Dec. 6, 7.30 p.m.
MANCHESTER
"Coke Manufacturing Problems," by Dr. G. E. Foxwell; "Coke Utilisation," by E. H. Coley; and "The Smoke Problem," by Dr. A. Semple. North Western Section. Engineers' Club, Albert-square, Manchester. Fri., Dec. 9, 2.30 p.m. (Luncheon at 1 p.m.)
SHEFFIELD
"Two-Stage Gas Producer," by P. Clarke. Yorkshire Section. Royal Victoria Hotel, Sheffield. Wed., Dec. 7, 2.30 p.m.

Institute of Industrial Supervisors

NEWARK
"The Foreman and the Metallurgist," by G. L. Harbach. Newark Section. Robin Hood Hotel, Newark, Notts. Tues., Dec. 6, 7.30 p.m.

Institute of Marine Engineers

LONDON
"The Paxman Engine," by A. G. Howe. Mon., Dec. 5, 6.30 p.m.*

Institute of Marine Engineers and Institution of Naval Architects

SOUTHAMPTON
"A Practical Approach to Some Vibration and Machinery Problems in Ships," by T. W. Bunyan. Southern Joint Meeting. Southampton Technical College, Southampton. Thurs., Dec. 8, 7.30 p.m.

Institute of Road Transport Engineers

BIRMINGHAM
"Accidents," by G. Mackenzie Junner. Midlands Centre. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham, 2. Tues., Dec. 6, 7.30 p.m.
CARDIFF
"Development and Operation of Disc Brakes," by T. J. Phipps. South Wales Group. South Wales Institute of Engineers, Park-place, Cardiff. Fri., Dec. 9, 7 p.m.
LIVERPOOL
"Injection Equipment, Including the Distributor Pump," by H. J. Stonemam. West Regional Centre. Adelphi Hotel, Lime-street, Liverpool. Thurs., Dec. 8, 7.30 p.m.
NOTTINGHAM
"Steering Geometry and Wheel Balance," by J. H. Hardman. East Midlands Centre. Mechanics' Institute, Trinity-square, Nottingham. Wed., Dec. 7, 7.30 p.m.

Institute of Welding

LONDON
"Measuring Productivity in Welding," by A. G. Thompson. South London and North London Branches. 2 Savoy-hill, W.C.2. Thurs., Dec. 8, 6.30 p.m.*

Institution of Chemical Engineers

LONDON
Papers on distillation problems. Geological Society, Burlington House, W.1. Tues., Dec. 6, 5.30 p.m.
CHESTER
"The Impact of Industry on the Young Chemical Engineer," by H. Fossett. North Western Branch. Grosvenor Hotel, Chester. Tues., Dec. 6, 7 p.m.
LEEDS
"Phenolic Effluent Disposal," by D. A. Hall. North Western Branch. The University, Leeds. Wed., Dec. 7, 7 p.m.

Institution of Civil Engineers

LONDON
"Planning of Ring Roads, with Special Reference to London," by F. A. Rayfield. Road Engineering Division. Tues., Dec. 6, 5.30 p.m.*
BIRMINGHAM
"The Civil Engineer and Britain's Atomic Factories," by D. R. R. Dick. Midlands Association. James Watt Memorial Institute, Great Charles-street, Birmingham. Thurs., Dec. 8, 6 p.m.*
NOTTINGHAM
"Design and Construction of 90 ft. Span Prestressed Pre-cast Concrete Roof," by Dr. D. D. Matthews. Midlands Association. Mechanics' Institute, Trinity-square, Nottingham. Tues., Dec. 6, 6.15 p.m.*

Institution of Electrical Engineers

LONDON
Discussion on "Private Generation from the Point of View of the User," opened by A. N. Irens. Mon., Dec. 5, 5.30 p.m.*
"The Instrumentation of a 14 in. Experimental Rolling Mill," by S. S. Carlisle and G. W. Alderton. Measurement and Utilisation Sections. Tues., Dec. 6, 5.30 p.m.*
"Some Half-Tone Storage Tubes," by R. S. Webley, Dr. H. G. Lubczynski and J. A. Lodge. Radio and Telecommunication Section. Wed., Dec. 7, 5.30 p.m.*
Discussion on "Aids to Teaching the Subject of Windings in Rotating Machinery," opened by F. Stefani. Education Discussion Circle. Fri., Dec. 9, 6 p.m.*
ABERDEEN
"Design Performance and Application of Miniature. Circuit-Breakers," by H. W. Wolff and T. G. F. Atherton. Scottish Centre. Caledonian Hotel, Aberdeen. Wed., Dec. 7, 7.30 p.m.
BIRMINGHAM
"Underwater Echo-Ranging," by Professor D. G. Tucker. South Midland Centre. James Watt Memorial Institute, Great Charles-street, Birmingham. Mon., Dec. 5, 6 p.m.
LEEDS
"Automatic Circuit Reclosers," by G. F. Peirson, A. H. Pollard and N. Care. North Midland Centre. 1 Whitehall-road, Leeds. Tues., Dec. 6, 6.30 p.m.*
LEICESTER
"Fuel Supplies of the Future," by D. Hicks. East Midland Centre. College of Technology, Leicester. Fri., Dec. 9, 6.30 p.m.
LIVERPOOL
"Transistor Power Amplifiers," by R. A. Hilbourne and D. D. Jones. Mersey and North Wales Centre. Electrical Engineering Department, The University, Brownlow Hill, Liverpool. Mon., Dec. 5, 6.30 p.m.
MANCHESTER
"TRIDAC: A Large Analogue Computer," by Lieut.-Commander F. R. J. Spearman and others. North Western Centre. Engineers' Club, Manchester. Tues., Dec. 6, 6.15 p.m.*

Institution of Engineering Designers

NEWCASTLE-UPON-TYNE
"Gear Design and Application," by S. Fearns. 6 Higham-place, Newcastle-upon-Tyne. Mon., Dec. 5, 7.15 p.m.

Institution of Engineers and Shipbuilders in Scotland

DUNDEE
"Light Structures: Research and Its Application to Economic Design," by Dr. R. M. Kenedi, W. S. Smith and F. Fahmy. University College, Dundee. Wed., Dec. 7, 7.15 p.m.

Institution of Heating and Ventilating Engineers

LONDON
"Overall Testing of Heating and Air-Conditioning Plants," by W. C. Ramsay. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Wed., Dec. 7, 6 p.m.*

Institution of Highway Engineers

BIRMINGHAM
"Developments in Concrete Engineering," by J. Singleton-Green. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham. Fri., Dec. 9, 7 p.m.

Institution of Mechanical Engineers

LONDON
Discussion on "New Fuel-Injection Systems." Internal Combustion Engine Group. Tues., Dec. 6, 6.45 p.m.*
"Some Experiments on the Deflections and Vibrations of Drilling Machines," by Dr. D. F. Galloway: and "The Vibrations of Radial-Drilling Machines under Test and Working Conditions," by Dr. S. A. Tobias and Professor W. Fishwick. Fri., Dec. 9, 5.30 p.m.*
LOUGHBOROUGH
"Knitting Machines," by William Bentley and B. P. Cooper. East Midlands Branch. College of Technology, Greenclose-lane, Loughborough. Wed., Dec. 7, 7.30 p.m.
OXFORD
"Jet Noise," by G. M. Lilley. Eastern Branch. Forum Restaurant, Oxford. Thurs., Dec. 8, 7.30 p.m.
READING
"Work Study," by R. M. Currie. Southern Branch. Technical College, Reading. Wed., Dec. 7, 7.30 p.m.

Institution of Production Engineers

LONDON
Symposium on "Unusual Aspects of Modern Press Works," Royal Empire Society, entrance in Craven-street, W.C.2. Thurs., Dec. 8, 7 p.m.
BRISTOL
"Aircraft Design for Production," by W. E. W. Petter. South Western Region Meeting. Engineering Laboratories, University-walk, Bristol 8. Wed., Dec. 7, 7.15 p.m.
NOTTINGHAM
"Colour as an Aid to Production," by Miss P. Raine. Victoria Station Hotel, Nottingham. Wed., Dec. 7, 7 p.m.

Institution of Structural Engineers

GLASGOW
"Advantages and Disadvantages of Structural Steelwork, Reinforced Concrete and Prestressed Concrete," by Donovan H. Lee. Scottish Branch. 39 Elmbank-crescent, Glasgow, C.2. Tues., Dec. 6, 7 p.m.
MANCHESTER
"The Influence of the Motor Vehicle on Urban Buildings," by F. M. Little. Lancashire and Cheshire Branch. College of Technology, Manchester. Thurs., Dec. 8, 6.30 p.m.

Junior Institution of Engineers

LONDON
Presidential Address on "Dams," by G. M. Binnie. Fri., Dec. 9, 7.30 p.m.

Modular Society

LONDON
Annual General Meeting and Open Discussion. Royal Society of Arts, John Adam-street, W.C.2. Mon., Dec. 5, 7.45 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE-UPON-TYNE
"Ship Structural Weight Similarity," by Professor E. V. Telfer. Mining Institute, Newcastle-upon-Tyne. Fri., Dec. 9, 6.15 p.m.

Reinforced Concrete Association

LONDON
"Concreting Problems and Methods in Hot Climates," by Dudley P. Harris. 11 Upper Belgrave-street, S.W.1. Wed., Dec. 7, 6 p.m.*

Royal Aeronautical Society

LONDON
"Fatigue Aspects of Structural Design," by W. A. P. Fisher. Tues., Dec. 6, 7 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Aslib (Association of Special Libraries and Information Bureaux), 4 Palace-gate, London, W.8. (WEStern 6321.)
Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chadwick Trust, 90 Buckingham Palace-road, London, S.W.1. (SLOane 5134.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Engineers' Guild, 78 Buckingham-gate, London, S.W.1. (ABBey 7315.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Industrial Supervisors, 24 Albert-street, Birmingham 4. (Midland 6971.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institute of Welding, 2 Buckingham Palace-gardens, London, S.W.1. (SLOane 9851.)
Institution of Chemical Engineers, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland-place, London, W.1. (LANgham 8847.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Highway Engineers, 47 Victoria-street, London, S.W.1. (ABBey 3891.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. (SLOane 4622.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GORsvenor 5254.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Modular Society, 22 Buckingham-street, London, W.C.2. (TRAfalgar 4567.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne, 1. (Newcastle 20289.)
Reinforced Concrete Association, 94-98 Petty France, London, S.W.1. (ABBey 4504.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)

In Parliament

ATOMIC POWER PRODUCTION

Many aspects of the production of atomic energy were raised in the House of Commons last week. In a written answer on Tuesday, Sir Anthony Eden, the Prime Minister, stated that the discussions between official representatives of the United States, France, Russia, Canada, Czechoslovakia and the United Kingdom at a private conference in Geneva in August, following the United Nations Conference on the same subject, were concerned with certain technical aspects of the problem of safeguarding fissile material against diversion from peaceful uses. Sir Anthony assured Mr. A. M. F. Palmer (Labour and Co-operative) that a useful exchange of technical ideas took place and that the problems arising would be further studied by the Governments represented.

Information respecting the Government's efforts to advertise in Europe and Asia the extent of Britain's achievements with atomic power stations was sought by Mr. Roy Mason (Labour), who also inquired what help the Government was prepared to give other countries in this field and what offer had been made, similar to that of the United States, respecting the supply of fuels at a reduced rate or on a rental basis to potential buyers of atomic power stations.

Considerable publicity for Britain's achievements, Mr. Nigel Birch, the Minister of Works, stated, was being given in all parts of the world by exhibitions, by publications of the Central Office of Information and the United Kingdom Atomic Energy Authority, and in other ways. A number of formal and informal collaboration agreements had been made with Commonwealth and other countries, and the United Kingdom was one of the sponsors of the proposed international Atomic Energy Agency.

No country had yet made specific offers of fuel for power stations. The United Kingdom had offered a limited amount of fuel for projects to be sponsored by the proposed international agency and arrangements for the supply of fuel for research reactors had been included in a number of United Kingdom agreements. Mr. Birch informed Mr. W. N. Warbey (Labour) that all uranium procured for use to the United Kingdom from the sterling area was paid for in sterling.

Mr. L. W. Joynson-Hicks, Parliamentary Secretary to the Ministry of Fuel and Power, told Mr. Warbey that he was unable to give revised estimates of electrical output and cost per unit in the case of the nuclear power stations to be constructed under the programme announced in the recent White Paper (H.M.S.O., Cmd., 9389).

TAXATION IN AID OF CRAFTSMANSHIP

Debates on the committee stage of the Government's new Finance Bill were continued in the House of Commons on three days of last week and two further days were allotted this week, when, the Government hope, the committee stage will be concluded.

During these debates, a discussion on the Government's application of purchase tax for other than revenue-raising purposes was initiated by Mr. Austen Albu (Labour), who suggested that the Government were adopting two somewhat contradictory lines of policy. He claimed that the Government had expressed a desire to curtail internal spending in order to release goods for export while, at the same time, they were proposing to give some help to the silverware and cut-glass industries by reducing the amount of tax paid on most of these craft products. These alterations, also, were aimed at giving more opportunity to exporters as well as providing more freedom for designers. He inquired whether the reduction of tax on gold and silver ware, with the avowed object of increasing the home market and with the help of what would be obtained from the export market, was likely to increase or reduce the import of the gold and silver required for manufacture.

It seemed that the object of these taxes was as much for planning purposes as to secure a reduction of the general level of consumer demand. Even in respect of goods of the handcraftsman type, there seemed to be two diametrically-opposed policies. A reduction of purchase tax on cut glass and gold and silver ware was proposed, but the tax on jewellery, in which a substantial export trade had been built up, was to be increased. Some types of leather ware were generally considered to be examples of British craftsmanship, yet, in this case, the tax was to be raised.

Normally, the argument in favour of home demand was that there must be a good home base to carry capital charges, overheads, design, and any research required, if there were to be exports in large quantities. This contention could hardly be applied to articles of the type being discussed, which were produced by hand, with simple tools and by traditional methods, especially when it was not being used in connection with durable consumer goods. The mass-production industries, making motor-cars, domestic equipment, electrical appliances, radio apparatus and similar equipment, on the other hand, did require very high capital charges before any products could be manufactured at all.

Mr. Ronald Bell (Conservative) put forward the view that, while the contribution of hand craftsmanship to exports could not hope to rival the production of the manufacturing industries, there was no reason why the contribution that it could make should not be welcomed. That contribution was made up of small amounts from a great many sources. There was no reason why the purchase tax should not be raised on goods of which it was desired to discourage home consumption, and lowered in special cases where it was wished to preserve, or slightly enlarge, the home market as a base for exports.

Industry's Aid to Technical Colleges

A question was asked by Sir Hugh Linstead (Conservative) inquiring if the Minister of Education would state the assistance he was receiving from the electrical, petroleum, chemical and other technologically progressive industries in this country in connection with his plans for expanding educational facilities designed to meet the shortages of qualified engineers and scientists. Mr. Dennis Vosper, Parliamentary Secretary, replied that these industries co-operated very closely with his Department in the planning of technical education, and with individual technical colleges in arranging courses and by paying for the attendance of students. They also helped many colleges by gifts of equipment and by encouraging their staffs to serve on governing bodies and to undertake part-time teaching.

Euston to Manchester Railway Electrification

Mr. John Boyd-Carpenter, the Minister of Transport and Civil Aviation, stated, in a written reply to Mr. C. L. Hale (Labour), that he was not in a position to make a statement regarding the commencement of the electrification of the main-line railway from Euston to Manchester. It was, however, the practice of the British Transport Commission to publish each year forecasts of the work to be undertaken under the modernisation and re-equipment programme during the following two years.

Locomotive Speedometers

Answering a question by Mr. Gresham Cooke, Mr. Boyd-Carpenter wrote that he did not propose to give a general direction to the Commission to fit speedometers to railway locomotives. He said that all new electric and Diesel locomotives built for the Commission under their modernisation plan were to be fitted with speedometers. It had also been the Commission's plan, since 1952, to fit speedometers to new steam locomotives designed for passenger and mixed traffic.

Employment in Production and Distribution

The Minister of Labour and National Service, Sir Walter Monckton, informed Mr. W. S. Shepherd (Conservative) than, since 1951, there had been an increase of 440,000 in the number of persons engaged in the production industries. compared with one of 193,000 persons in the distributive industries. But, as the number of people engaged in production was much larger than that engaged in distribution, the effect was that for every 100 persons engaged in distribution there were 480 in production in 1951 and 460 in 1955.

Steel Supplies for Shipbuilding

In answer to a question by Mr. Arthur Blenkinsop (Labour), Commander Allan Noble, Parliamentary Secretary of the Admiralty, said that he was aware that shipbuilders and ship-repairers in general, including firms on the North-East Coast area, were becoming apprehensive about their steel supplies. The First Lord of the Admiraly was in close touch with industry on the matter and the situation was being carefully examined with the Iron and Steel Board. The First Lord would look into particular instances if full details were sent to him.

Subsidies for Foreign Shipbuilding

Of the foreign countries with important shipbuilding industries, for which information was available, five assist with subsidies the building of ships for their own fleets, according to an answer by Mr. A. R. W. Low, Minister of State to the Board of Trade, to Mr. J. R. H. Hutchison (Unionist). Four of these also assisted in various ways the building of ships for export; but in one of them, the arrangement for doing this was due to lapse at the end of this year.

Exhaust Gases from Motor Vehicles

During the last twelve months, Mr. J. R. Bevins, the Parliamentary Secretary to the Ministry of Works, told Mr. Albert Evans (Labour), the Fuel Research Station had measured the concentrations of carbon monoxide in the air caused by the exhaust gases of motor vehicles at a number of sites in London. The average concentrations ranged from less than one part of carbon monoxide per million parts of air in the centre of Hyde Park to 27 parts per million above the pavement in Oxford Circus at times of heavy traffic. These concentrations were well below the levels which would constitute a danger to health. The investigation of other pollutants in exhaust gases was being considered.

Central Vehicle Repair Depots

Answering a question by Mr. I. J. Pitman (Conservative) as to the expenditure incurred in setting up the centralised workshops of his Department, Mr. Reginald Maudling, Minister of Supply, stated that £571,000 was spent on adapting and equipping Government-owned premises as central vehicle-repair depots and that, in addition, surplus Government-owned plant and equipment, which had originally cost £266,000, had been provided.

Capacity of Atomic Reactors

In a written answer to Mr. W. N. Warbey (Labour), Mr. Nigel Birch, Minister of Works, said that the capacity of the six additional atomic reactors to be erected by the Atomic Energy Authority, in accordance with the announcement made last June, would be about 200 megawatts. It was too soon yet to say exactly when these reactors would come into operation, but it was likely to be in 1959 or 1960.

Agricultural Machinery Engineers

Sir Walter Monckton told Mr. George Jeger (Labour) that he was unable to extend exemptions from national service to engineers mainly engaged on agricultural machinery. Sir Walter added that a great part of the engineering industry was employed on work of national importance and he was not prepared to single out one section of it for exceptional treatment.

THE HUMAN ELEMENT

The problems of being an individual in organised industry—The next A.E.U. president?—From research work to management—Pending disruption in trade-union Germany—Political buying power of the lower-paid workers—Raising group morale, lessons from the R.A.F.

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Human Rights and Corporate Interests

We have travelled far in the past 20 years towards personal security, in our jobs and our private lives. Very few of us, workers, traders, or employers, cannot look to some form of association, or union, for the protection of our interests—whether they be price maintenance, conditions of employment or wage levels. But greater personal security has a heavy price, or two prices, that must be paid.

The first is a surrender of personal liberty, of the right to walk alone if doing so is thought to endanger the security of others. The second is the price which was paid by faster ships during the war when seeking the safety of convoys: the sacrifice of personal performance when it differs from the norm. Too often this has meant adopting the pace of the slowest, or accepting the advice of the most cautious. There are times when the individual rebels and breaks away—the manufacturer to cash in on his ability to make goods cheaper than his competitors or the worker to earn a higher output bonus than his team mates. Sanctions follow, sometimes expulsion from the association or trade union, and there have been times when such sanctions have fired the public at large with indignation. But it is as well to remember the price we have to pay for security, for only the very strong and the very daring among us would care to do without.

At the Scottish factories of Rolls-Royce, a polisher was expelled from his union, the General Iron Fitters Association, some five weeks ago for disregarding an unwritten agreement between the 48 men in his shop to limit bonus earnings during a slack period, or so the story goes. The company, whom he had served for over 12 years, refused to dismiss him. An unofficial strike of the 7,500 employees began, over the simple-looking issue of trades union members refusing to work with a non-trade unionist. After some hesitation, the 13 unions concerned met last week and recommended that the strike should be recognised and made " official ": two of them, the G.I.F.A. and the A.E.U. have already done so and are said to be back-dating strike pay to the day the dispute began. The logic of the unions' case is unshakeable; the equity of the company's stand is unexceptionable.

Sympathetic understanding of both these stand-points could do much to bring about an amicable settlement. Suggestions, however, that if the agreed procedure for preventing disputes had been followed there would have been no dispute, or that the company's 3,500 salaried staff should man the machines (or be dismissed) can do little but exacerbate the situation and discredit the management, who at present have the country's sympathy for their courageous stand on behalf of the individual.

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The A.E.U. Hustings

The nominations of candidates for the presidency of the Amalgamated Engineering Union—the second largest union in the country—closed two weeks ago. The election, to begin very soon, will take 11 months to complete but most of the candidates are now known. The president of the A.E.U.—at present Mr. R. Openshaw until he retires on reaching the age limit of 65 next September—is one of the V.I.P's of the movement. Candidates are not always easy to find, since paid officials of the union have to relinquish their posts if they wish to stand, with the prospect, if not elected, of having to return to the work bench. One of these men, Mr. W. J. Carron, who is a member of the national executive council, does intend to stand and is a clear favourite. Two others who have a sizeable backing, Mr. H. G. Barratt and Mr. R. Birch, are not tied to a paid union job.

Mr. Birch is a communist, and Mr. Carron a determined anti-communist and a Roman Catholic who has been a full-time officer of the union since 1935 and a member of the executive council since 1950. Mr. Birch is president of the North London district committee of the Union and a member of the final appeal court. Between these two extremes comes Mr. Barratt, and there may be others. Probably it is among these that the winner will be found, unless enough union members vote to exclude the Communist candidate at the first round.

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The Leaders and the Led in Germany

The leader of the German trade union federation, Herr Freitag, is finding that to be public spirited brings a heap of troubles. German workers are now less patient than they were, particularly the iron and steel workers of the Ruhr. Herr Freitag is also discovering that trade unionists who sit on the boards of companies, as is the policy under Germany's " co-determination " arrangements (a post-war development) are not popular with the rank and file, in fact are no longer considered to be the representatives of the trade unions. The federation is being criticised for being too moderate and conciliatory, whether in industrial disputes or towards the Federal Government, or in its attitude to the threat of a separate " Christian " union movement.

The mounting opposition to Herr Freitag is symptomatic of German workers' new attitude, born of full employment. There is the beginning of a move away from top union leadership, led by the iron and steel workers. They have recently resolved to pursue their dispute with the separate undertakings in the industry, backing their demands with strike threats. This is a complete reversal of policy which so far has been to press for general industrial negotiations and standard agreements. The employers have replied by announcing that they will on no account make separate bargains.

These developments suggest that mistrust lies deep between the leaders of the German trade union movement and the rank and file, and that the latter know their strength and are prepared to use it. They have certainly much leeway to make up if they are to catch up with the standards of pay, working hours, and conditions enjoyed by workers in the United Kingdom.

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Sugared Pill from the T.U.C.

Second thoughts from the T.U.C. do not appear to have seriously altered its views about the autumn Budget. It would still have preferred higher direct taxation on larger incomes and restriction of imports to higher purchase tax as a means of controlling consumption. This is much better politics than it is economics for it makes the quite unwarranted assumption that consumption can be limited adequately by touching only higher incomes and that you can mop up purchasing power by reducing imports. The second assumption is quite wrong, and the first one evades the fact that the bulk of the purchasing power is with the lower income groups.

That said, however, there are plain signs in the latest T.U.C. statement that it sees the unwisdom of the unions forcing up wages where these can in turn only force up prices. It calls for a responsible attitude from trade unionists on this issue and points out that the rest of the world does not owe the British workpeople a living. Nothing much stronger than this could be expected from the T.U.C. at a time like the present, for its influence as a responsible body lies in it being only fractionally ahead of its members on matters of public policy. In the end, like the F.B.I. on the other side of the argument, the T.U.C. has grave reservations about official economic policy at the moment, but its philosophical doubts are well diluted with a sense of its public responsibility.

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Research Manager in Industry

How close should the research manager be to the " line " command in a company? This is one of the issues raised by Dr. B. K. Blount, deputy-Secretary of the Department of Scientific and Industrial Research, recently in his E. Frankland Armstrong Memorial Lecture to the Royal Society of Arts. He points out the dangers of having a company's research activities separated too far either mentally or geographically from the production units. Put another way, Dr. Blount wants the research manager close enough to the production men to affect them by the stimulus of his ideas, but thinks that the research department is not in a position to fix the research programme itself.

He recalls the example of the war when scientists were sent forward to get first-hand impressions of problems and the circumstances in which solutions had to be applied. A similar approach is proposed for industry so that the research manager would gradually get into the frame of mind where he wishes to run the company's production himself eventually. There is much to be said for such an idea. Many a research man has eventually run a company successfully, learning many things he never thought of in his laboratory as he has been promoted into senior administrative positions. But there is one important qualification. Running a concern, especially to-day, is not merely a question of applying good ideas to production lines—fewer managers would go prematurely grey if it were. Management is a process of compromise, diplomacy, patience and preoccupation with dozens of petty issues which are vital in total but only indirectly connected with actual production. This is not the research worker's familiar world, but if he can get acclimatised to it he is certainly worth his weight in gold.

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Group Morale

An unusual and stimulating addition to the literature about morale in industry has recently been made by Dr. T. T. Paterson, senior lecturer in industrial relations at Glasgow University, in his book *Morale in War and Work*. Broadly and briefly, its thesis is the importance of giving work in industry to-day a " meaningfulness " by building up group morale (often where old groups and loyalties to fellow-workers have been destroyed, as in the case of coal mining, by mechanisation). Such morale, says the author, can be built up by stimulating unofficial leadership within a group of workers. Thus men find satisfaction with work and identify themselves harmoniously with the working group where morale has previously been low, when they can find (often unconsciously) this meaningfulness. The theory is thus a group concept, but it differs in important respects with much that has been written about " the group " in industry.

The vividness, readability and originality of this book lie in its being based on a series of war-time experiments on a home-based R.A.F. fighter station where morale was low and the accident rate in aircraft high. The book is an account of how this problem was analysed by the author and solved. At the end there remains a nagging thought. In the book (as in many of its kind) intelligent men were unable to get the right answer by the old methods because they stuck to worn-out formulas instead of examining the situation and thinking. What about the new formulas? Is there a danger that in time these also will be preserved to mislead, while the original thinking which produced them and was most of their justification is discounted?